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INTERIM REPORT OF THE ACMRR WORKING PARTY ON THE SCIENTIFIC BASIS OF DETERMINING MANAGEMENT MEASURES

Rome, 6-13 December 1978

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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FOREWORD

The ACMRR Working Party on the Scientific Basis of Determining Management Measures was established by ACMRR at its Ninth Session in Rome, June 1978, and held its first session in December 1978. At that session it was recognized that if the Working Party was to execute its task fully and effectively, it would have to interpret its terms of reference in a wide sense, and take a broad view of the problem of fishery management. The discussion at its December 1978 session therefore covered a large number of topics, some in detail, but inevitably some only superficially.

FAO believes that the picture of fishery management and its associated problems, as set out in the present interim report, is of great interest to all those concerned with management, particularly those now having to set up a national policy and structure to manage those resources coming under national control as a result of extended jurisdiction. FAO has therefore arranged for the distribution of the report which the Working Party feels is in a preliminary form so that the ideas expressed in it can be of some immediate help in tackling these new and urgent tasks. The Working Party stresses that the present interim report is in no way a comprehensive review of the subject and that many of the topics are discussed only sketchily. For example, the definitions in section 4 represent only a first attempt to codify terms that have been used in various, and sometimes confusing, ways. To this extent the present document should be used more as a stimulus to thought than a source of definite answers.

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1. Introduction

At its Ninth Session (Rome, June 1978) the Advisory Committee on Marine Resources Research (ACMRR) discussed at some length the methods of determining allowable catches, and other questions relating to the rational management of fish resources, particularly in the light of extended jurisdiction (see paragraphs 21-30 of its report). In view of the complexity of the subject, and the need for detailed examination of it, including the preparation of critical reviews of certain aspects, ACMRR decided to establish a working party with the following terms of reference:

(i) to review the concepts, principles and definitions used in resource conservation and management;

(ii) to examine the validity of existing biological models as applied to the new concepts of management, the range of species and ecosystems being exploited and economic models of resource management;

(iii) to develop new models as required;

(iv) to advise on the implications for research studies and for the data base that will be needed; and

(v) to examine special requirements for scientific advisory systems in the case of shared stocks.

ACMRR agreed to ask Dr. B.J. Rothschild to serve as Chairman of the Working Party, which he accepted. The membership of the Working Party was subsequently agreed in correspondence between the Chairman of ACMRR (Dr. D.L. Alverson), Dr. Rothschild and the Secretariat. In addition, a number of other highly qualified specialists were invited to take part in the activities. The first meeting of the Working Party was held in FAO Headquarters, Rome, from 6-13 December 1978. A list of those attending is given in Appendix 1. It was noted that though many of the problems of management were independent of the new Law of the Sea and the establishment of exclusive economic zones (EEZs), the new situation had increased the opportunities and the responsibilities of coastal states to manage their resources, and the fisheries based on them. In this connection the meeting provided FAO with a good opportunity to consult with a number of senior administrators in developing FAO's programme of EEZ assistance.

In preparation for the meeting each participant was asked to prepare a short 'mini-paper', setting out some of the problems in fishery management. A list of these (including an extract from a letter from Mr. B.B. Parrish, who was unable to attend the meeting) is given in Appendix 2, which also lists a number of other papers which were found relevant to the work. The presentation and discussion of these mini-papers brought out a number of points of general relevance to better management in addition to those concerned with the specific topics discussed under later items of the Agenda.

2. General Problems of Management

2.1 Effects of extended jurisdiction

The extension of jurisdiction and the establishment of EEZs has a fundamental effect on resource management. Many of the problems (e.g., on the possible establishment of "exclusive" or "Sovereign rights") will be made much easier to solve as a result; others will be unaffected, while EEZs do raise a number of new problems, e.g., management of shared stocks. The nature of some of these problems is not well understood, and the impact of EEZ, and other aspects of the emerging Law of the Sea needed further examination (see Section 6.1). It was strongly emphasized that several of the opportunities to benefit from EEZ were essentially transient. For example, reduction or elimination of foreign fishing could allow the total fishing effort to be maintained at a level giving greatest social or economic benefits, rather than expanding to a level at which most or all of the benefits are dissipated. However, the chance to implement the necessary controls relatively painlessly only lasts so long as the coastal state, in replacing foreign fishing fleets by vessels under its own control, has not allowed the total fishing capacity to expand beyond the optimum. It was recognized that taking account of joint venture, charter, and similar arrangements, a coastal state could build up its capacity very quickly to levels which, in the absence of good advice, could well exceed the optimum. While there is widespread recognition of the opportunities for development and expansion of local fisheries provided by EEZs, there is less general appreciation that these may prove disappointing unless at the same time the opportunities for management (in particular the management of fishing effort) are also grasped. FAO was therefore strongly urged by the Working Party to take the initiative in pointing out these management opportunities, and assisting countries to take advantage of them. It was felt that this should be a central element in FAO's EEZ programme of assistance to developing countries.

2.2 Special needs of developing countries

The Working Party stressed that its prime goal was to assist developing countries, but that in relation to management there was not a simple dichotomy between developing and developed countries. The ability to manage well involved many factors - the absolute size of the fishery, its importance in the national economy, the resources that can be made available to carry out fishery research, the social and political structures that generate the flow of information and decision-making among fishermen, scientists, administrators and others. Developed countries tend to occur at one end of each of these spectra (bigger fisheries, more resources for research) and developing countries at the other, but there are, for example, several developing countries with large fisheries or large fishery research capacities. Conversely some developed countries have small fisheries or inefficient research machinery. The Working Party therefore felt that while concentrating on the problems of developing countries, the experiences of developed countries of how they had tackled their problems were likely to be relevant. Equally it stressed that the discussions and conclusions of the Working Party were likely to be relevant to developed countries.

2.3 Past performance in management

The past experience in managing fisheries was referred to, generally rather critically, in several papers. In discussion it was observed that the management record, taken as a

whole, was at least satisfactory when measured against support given to management programmes (including necessary research) or compared with what would have happened if there had been no management. However, in this regard distinction needs to be made between the biological aspects of resource management, and the economic and social aspects of fishery management.

On the biological side, there has been, on the whole, and with certain obvious exceptions, fair success in maintaining stocks. In some of the more obvious failures, e.g., some herring stocks, the failures have not been in the existence or quality of scientific advice, but in the unwillingness of decision-makers to act in response to that advice. There have been instances, e.g., other herring stocks, in which inadequate biological advice (and in particular the advice given at those early stages of the decline of the stock at which advice would have been relatively easy to act upon) had led to serious decline of the stocks, and other instances where there have been significant error in the advice, though with less serious consequences to the fish stocks. While it might reasonably be claimed that these have been no more frequent than it would be reasonable to expect, given the volume of advice sought, and the resources available to provide that advice, these scientific failures have been damaging to the fisheries concerned, and to the general credibility of scientists in advising managers. Here it was noted that the establishment of EEZs, and the increasing pressure on the fish stocks, is resulting in a very much greater demand for biological advice, both in respect of the details asked for, and in the number of fish stocks concerned. Without a general strengthening of research capacities, or a re-examination of the processes by which advice is given, there must be serious doubt whether the past standards in the biological advice can be maintained, let alone the improvements achieved in timeliness and reliability which are clearly desirable. This is discussed further in Section 5 of this report.

In contrast, on the social and economic side, past performance of managing fisheries is much worse. It is doubtful if there are many mature modern fisheries (i.e., excluding those still in the early "boom" phase of development) that are making efficient contributions to national economies, particularly if costs of management (including research, administration and enforcement) are taken into account.

The effects of unlimited expansion of fishing effort on fishery resources harvested nationally and internationally have been repeated again and again for many single and multispecies resources. These general effects have a well established basis of bioeconomic theory. Fishing effort expands to a level where potential economic benefits to the fishing sector are dissipated and may become negative if fishing is provided with continuing financial support as a matter of government policy. Typically fishing effort will then exceed the level needed to achieve the MSY, it may lead to a sustained reduction in the number of young fish that enter the fishery, and it will in most cases lead to increased qualitative and quantitative variation in the catch. This variability adds short-term economic instability to an average long-term level of economic productivity that is very low.

2.4 Communications

An important reason for the failure to appreciate the full potential social or economic benefits from management has been an imperfect communication of technical analyses of the biological and economic consequences of management actions to decision-

makers. In many fisheries and fishery administrations there is indeed no clear identification of who are the important actors. Discussions in the Working Party emphasized that there were many actors (e.g., those responsible for investment decisions) whose actions were crucial in determining the success or otherwise of management, who were not generally included in management plans. The identification of all the significant actors and the actual links between them are needed so that managers can identify all appropriate decision points and take whatever actions are appropriate regarding these.

The management process involves two streams of activity: (i) the supply of information to decision-makers, and (ii) the patterns of influence whereby decisions are implemented. Figure 1 is a schematic representation of information flow from the resource and industrial sectors, through or past technical advisers to a number of interest groups who may adopt policies and attitudes which directly influence industry, or which influence decisions made at a political level. The list is not exhaustive, nor are all groups represented in all fishery situations and there are additional information links, particularly by "vertical" communication between sector groups but the lines indicated do show a fundamental horizontal stratification. There is a major flow between the extraction process and its downstream activities to secondary industry, financial resources and government departments with an indirect and broad societal interest in the fortunes of the fishery industry. There is a second stream of information concerned with the availability of the raw material as a renewable resource flowing from technical advisers to fishery administrators. This group has the broadest overlap of interest relating raw material supplies to policy in the dependent industry. But it is noticeable that very little information on raw material supply is solicited by or readily available to the secondary industry and investment areas which have a profound influence on the development of a fishery.

Figure 2 sets out the complementary patterns whereby decisions may influence the development. Again this is not exhaustive but again it illustrates stratification. Financial institutions, secondary industry and related government departments can and do influence the level of exploitation directly and in a way which is not responsible to the administrators implementing a fishery management policy except through the overall political decision process. It is also evident that the decisions which influence the rate and level of expansion in fishing are as highly fragmented as the industry itself.

The consistent pattern of apparent over-capitalization in developed fishing industries can be directly associated with the investment process and, as Figures 1 and 2 show, this is an area which does not appear to be subject to any regulatory control responsive to the fishery management system. The key problems in fisheries management appear to the Working Party to be the institutional difficulties of:

(i) the development of appropriate regulatory controls of the investment process either directly, or by establishing investment ceilings by allocation of exclusive rights;

(ii) ensuring appropriate communication systems so that all decision-makers or concerned individuals are aware of the implications of the decisions, and

(iii) the technical problems of establishing the capitalization appropriate to a particular fishery-management objective.

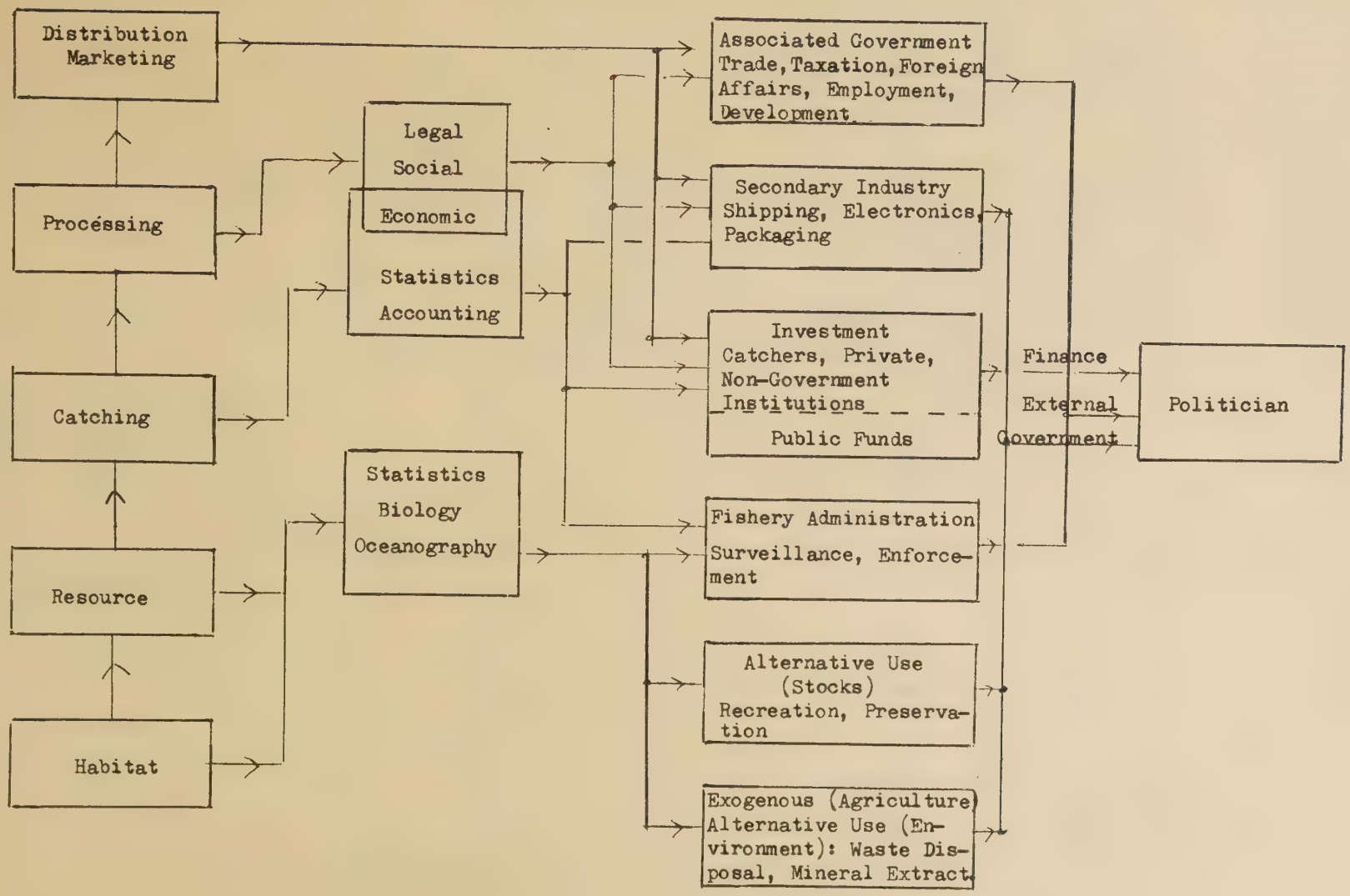

FIGURE 1. INFORMATION FLOW

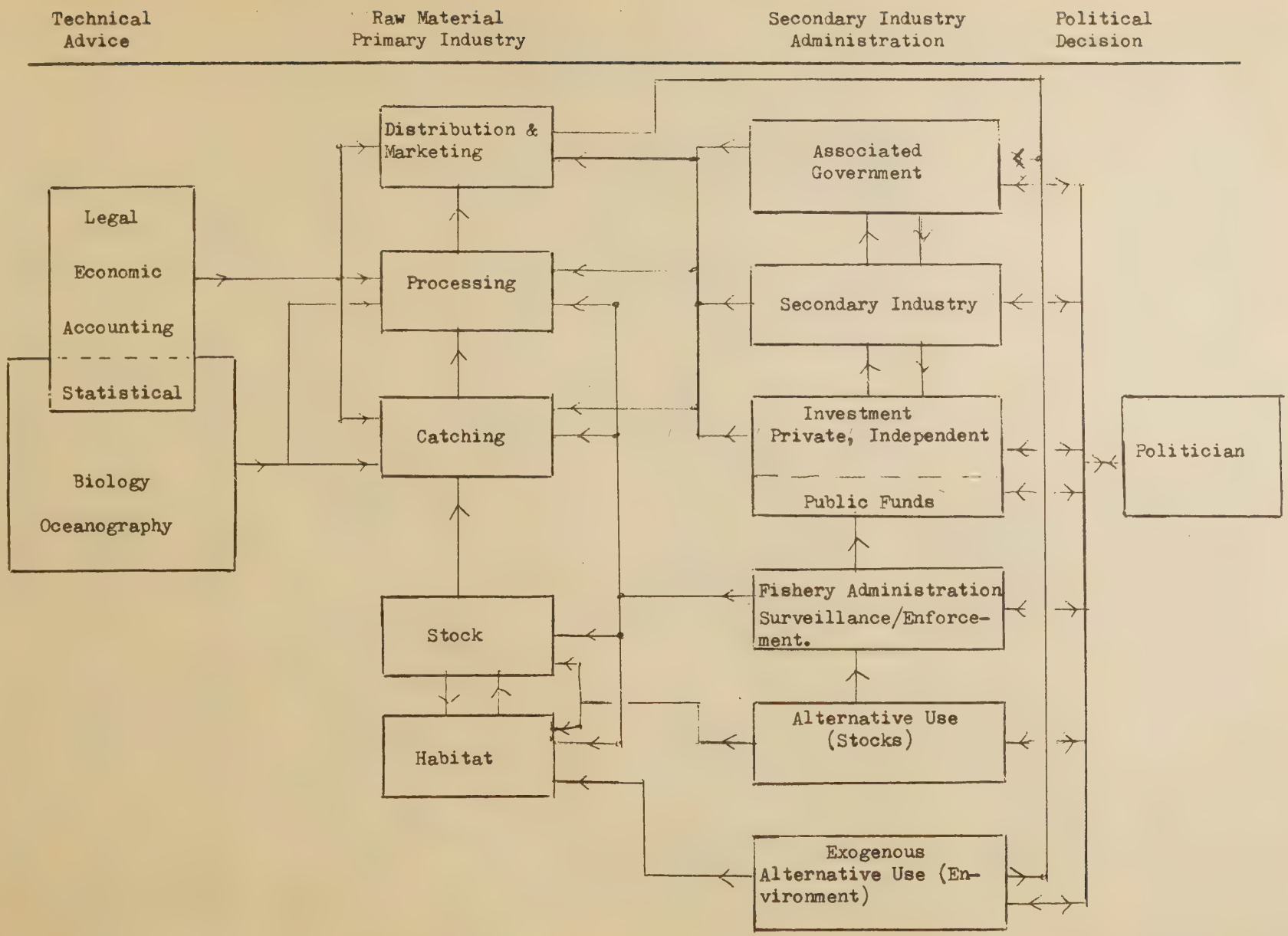

FIGURE 2. MANAGEMENT INFLUENCE

These questions especially concerning improving communications need further study (see Section 6.6). In addition the discussions concerning the responsibilities and activities of the different groups identified in Figures 1 and 2, and the links between, showed that there was a great need for a closer examination of many of the processes involved in fishery management (see Sections 6.7 to 6.13).

2.5 Objectives

The ultimate limit of fleet expansion is determined by biological constraints on fishing effort which, if exceeded, lead to stock collapse. Thus an important objective in any fishery is to ensure that exploitation does not lead to such a collapse. In addition, there is an infinite range of biological, social, economic and political objectives determined by local circumstances. Each of these objectives, if followed, could lead to a different pattern of harvest or exploitation. But whatever objective is selected the central management problem is to judge the amount of fishing appropriate to that objective and to regulate it at that level.

The question of objectives, and the precise definition of objectives, has received much attention. The Working Party believed that too much attention could be paid to attempting to make a rigid definition of the objectives of fishery management. What is important is the clear recognition that there are different classes of objectives - biological, economic and social - as well as different time horizons over which the objectives might be attained. If one objective is given attention, and another ignored, or the long-term interests subordinated to immediate short-term interests (or vice-versa), the results could be disastrous. It was essential if fisheries are to make the contribution they could make to national well-being (however defined) that management has clear and explicit objectives in addition to the purely biological ones that have tended to dominate fishery management (or more exactly, resource management) in the past. This must not be taken to mean that biological considerations can be ignored. Just the reverse: it is almost impossible to get good economic or social returns from a fishery unless due attention is paid to the resource constraints, and the resource maintained in a healthy and productive state. However, this attention to the resource management should, in general, be seen as a means towards social or economic ends, rather than an end in itself.

2.6 Exclusive Rights

Traditional management procedures in marine fisheries have concentrated on managing the resources by means of techniques such as limiting the annual catch, regulating the size of fish captured, closing spawning or nursery areas, and so on. While such intervention has often been successful in preventing stock depletion (and sometimes in bringing about the recovery of previously depleted stocks), the problems of dissipation of economic revenues is seldom resolved by these techniques. Instead of being evidenced by stock depletion, an economic situation which is thought to be undesirable, now shows up in terms of over-capacity of fishing fleets (and possibly of the processing sector), and a corresponding and often progressive shortening of the fishing season. A corollary of this process is an increase in the difficulty of controlling catches, especially in circumstances where natural fluctuations in the stock require temporary reduction in catch.

(Before continuing, it should be noted that various positive economic and other benefits may well be produced under the circumstances described above. These would include

the generation of consumer surplus, the maintenance of a valuable supply of food or industrial products, the provision of employment of fishermen and subsidiary workers, generation of foreign exchange, etc. Nevertheless, economic losses in the fishing and processing sectors may be significant).

It seems to be generally agreed among analysts of fisheries economics that the underlying cause of these economic problems lies in the open access to "common property" fishery resources. The establishment of Extended Jurisdiction is a first step towards replacing the open-access system by a more rational form of jurisdiction. However, extended fisheries jurisdiction by itself does not necessarily establish exclusive ownership. The LOS negotiating text restricts coastal states' rights somewhat by requiring that "surplus allowable catches" be made available to foreign vessels under certain conditions. Moreover, exclusive rights to transboundary and migratory stocks are clearly not implied by Extended Jurisdiction.

As is the case for any real asset, rights to fishery resources can exist in a wide variety of forms and degrees, ranging from "sole ownership" to completely open access. As already noted, extended fisheries jurisdiction implies the vestment of rights to certain fishery resources within the 200-mile zone to a well constituted authority, the coastal state. It seems certain, however, that management of the amount of fishing effort applied to fishery resources under the jurisdiction of coastal states will become necessary if desired economic benefits are to be fully realized. In the case of shared stocks, agreement of catch allocation between states can provide each state with specified rights to these resources.

The next level of restriction, generally referred to as "limited access", confers exclusive (if not unlimited) rights to exploitation upon a specific group of fishermen, normally under a licensing programme. However, unless these licensed fishermen are further restricted, or otherwise controlled, as to vessel capacity, areas or time intervals fished, or amounts of fish caught, the incentive remains to dissipate economic benefits through competitive over-expansion of inputs. These incentives may be interrupted either directly, by means of catch allocations, or indirectly, by means of economic instruments such as taxes or royalties. In the latter case, basic ownership of the resource will rest with, and the economic revenue deriving therefrom will accrue to the state; in the former case, ownership may essentially be conferred upon individual fishermen or fishing firms, although the state may employ various methods to extract some of the net economic revenue so generated.

The ultimate choice of an appropriate regime of exclusive rights to fishery resources is by no means obvious at the present time. Possibly because of the very newness of Extended Jurisdiction, very little attention has yet been directed to many of the fundamental problems that can be expected to arise.

2.7 Variability

Fisheries operate in a highly variable environment. Year-classes of important species can vary by two orders of magnitude, and some stocks can fluctuate between abundance and almost complete absence over periods of decades. Nevertheless, most of the concepts and models used in the fishery-management system are based on an implicit assumption of a steady state. Failures to take account of variability, and the fact that few if any

fisheries or fish stocks are in a steady state can exacerbate the difficulties already noted. For example, instead of "bad" years having the effect of driving out at least some of the excess effort in a heavily fished stock, their impact is often lessened by subsidies or similar government intervention. The subsequent "good" years then attract even more excess effort into the fishery. Greater account needs to be taken of variability at all stages. For example, it might be valuable to siphon off some of the benefits in good years to build up an insurance against later bad years. The Working Party only looked at this general subject rather superficially, and believed it deserved much more study (see Section 6.4).

3. Shared Stocks

3.1 General considerations

Many stocks are fished by more than one country, and their management obviously requires close coordination between the countries concerned. This is particularly true for shared, or transboundary, stocks, i.e., those that move across the boundary between the areas of jurisdiction of two adjacent coastal states, but is also true when one country fishes in the EEZ of another country, and for stocks that occur and are exploited, partly or wholly, outside national EEZs.

It was noted that administrative problems are increased when stocks are shared. There is therefore a tendency on the part of fishery administrations to act on the supposition that stocks are not shared. This assumption is also politically attractive, since it allows countries to determine fishery policies in respect of a stock without reference to possible interactions with fisheries of other countries. This could lead to difficulties, including severe damage to the stocks and the fisheries on them, if indeed the stocks do cross the boundaries of national jurisdiction, and there is significant interaction between fisheries in different EEZs. There is therefore an urgent need, on which FAO might take action, in identifying which stocks are shared.

Management of these stocks involve the following stages, at each of which certain problems can arise that are different from those concerning stocks that are solely the concern of a single country:

(i) Compilation of data.

(ii) Analysis of the state of the resource, and of the effects of different management policies.

(iii) Establishment of general management policies, e.g., the determining of TACs.

(iv) Identification of specific national actions to implement these policies (e.g., allocation of national shares in the TAC).

(v) Enforcement and implementation of these actions, including measures to enable all countries to see they are being enforced.

3.2 Data compilation

The basic data needed to advise on management of stocks of multi-national interest are the same as those needed for those of concern to only one country, but their collection

and compilation present special problems. While both biological and economic/social data are relevant to the provision of advice, it was agreed that the problems of expressing the latter type in a standard form (and also the possibilities for provision of incomplete or misleading economic data) meant that the international compilation of data should be confined to resource data (catch and effort statistics, and biological data).

Of these, the most important was statistics of total catch; unless those analyzing the state of the stocks know the total removals from that stock they have little chance of reaching sensible conclusions. This minimum information should be complemented by information on the timing and location of catches, associated fishing effort, and biological data such as size composition.

Where one country is fishing in the EEZ of another, the detailed data requirements, and arrangements for reporting will normally be agreed through bilateral negotiations, and the data exchanged bilaterally. The same could be true in respect of stocks shared by adjacent coastal countries. However, it was felt that it could be helpful in these discussions if FAO were to provide some suggestions of the details of the data that might be supplied, as well as the format that might be used in reporting and on the timing of reports (e.g., weekly, monthly or annually). This is a matter that might be considered by the Working Party after the present session (see Section 6.2).

Where there are only two countries a mutual exchange of data might be sufficient; if three countries are interested in the same stock, the exchanges of data to ensure that all parties have all relevant data become more complex, and with more countries concerned (e.g., for species undertaking lengthy migrations), the desirability of a central data repository clearly increases.

It was suggested that there could be advantages in an independent data base, free from possible distortations present in national data, but it was recognized that this was unrealistic. More realistic was the possibility of an independent agency (e.g., the secretariat of a regional body responsible for central data repository) acting in some way to check or referee the data supply, and especially to assist in improving the reliability and credibility of data supplied to coastal countries by foreign fleets.

It was pointed out that in the past data supply had been used as a lever in the negotiations on management (particularly on the level of TACs and their allocation). Often countries providing an early supply of good, accurate data had gained no special advantage in the negotiations. Some countries have also perceived at least a short run advantage in not producing good data, in that in the absence of the conclusive evidence that might arise from good data, the presumption has usually been that the less restrictive options (e.g., higher TACs) should be adopted.

In the present situation in which it is generally recognized that the supply of statistical and other data should be improved, but countries as a whole do not act to achieve this improvement, more is required than further recommendations to supply better data. It was stressed that membership of FAO carries with it the constitutional responsibility to supply data, and that FAO should take the leadership in respect of data improvement. This subject is therefore one that should receive further detailed attention of the Working Party (see again Section 6.2). The long-term benefits of improved data should be stressed. In addition, management practices could be modified to provide clear incentives

to providing improved data. For example if, in the case of inadequate data leading to indeterminate advice on, say, the level of TACs, the more conservative estimates were always taken, there would be an immediate incentive for those wishing to take larger TACs to supply better data.

3.3 Analysis of the state of the stocks

The biological analysis to determine the general state of exploitation of a shared stock involves the same technical problems as the analysis of a stock within a single jurisdiction. Some additional analysis may be required for shared stocks in order to provide advice on matters of allocation; this could involve determining migration patterns, the existence of possible separate stocks or sub-populations, and the estimation of the quantitative effect of different distribution of the total fishing effort, especially between various national sectors. There was some discussion on how the best scientific talent could be applied to this work, and how it could be ensured that the result represented the best available scientific advice. The advantages, in principle, of some type of "peer review" were stressed, though it was not entirely clear how this could be provided in many situations. Discussions within regional bodies sometimes provided good opportunities, but it was noted that the fragmentation of scientific advice as a result of EEZ had in some cases tended to reduce their effectiveness in this regard.

The desirability was also stressed of administrators understanding the processes by which scientific advice was formulated. It was noted that in some cases administrators had come to believe that the scientific advice was too conservative; this could lead to attempted "second guesses", with scientists giving progressively more conservative advice in order to produce the desired action. That is, the essentially political/administrative decision on whether to take a more or less conservative action tended to be taken in what should be a scientific activity. This introduction of political factors into the scientific discussions was particularly likely to occur when the general management regulations were such that the scientific conclusions immediately determined the management measures that should be taken (e.g., the New Management Policy of the IWC). It was very important that the scientific (advisory), and administrative/political (decision-making) processes be kept separate, but that at the same time that administrators understood how the scientific advice was arrived at.

3.4 Establishment of management policies

The most usual way in which common policies in respect of shared stocks is expressed is in the establishment of TACs, although this is not necessarily the only option. It was also stressed that while much of the negotiations in respect of shared stocks was traditionally concerned with the allocation of shares in the TAC, the determination of the TAC itself required the resolution of possible conflicts. For example, if one country had as a major objective a large stock, and thus high catches per unit effort, leading to profitable fishing, and another country wanted a high total catch in order to improve the food supply, they would be interested in quite different levels of TACs.

Such conflicts could not be wholly resolved by modifications in the share of whatever TAC was established - in the example above the first country could hardly be satisfied by an increased share in a fishery which it found economically unprofitable. However, there were other methods of adjustment that could be taken into account, for example by transfer of payments of one kind or another.

Where two countries of greatly different negotiating strength (e.g., in terms of supply of research data) there was an obvious danger that the stronger party could dominate the negotiations. It was possible that regional bodies could help reduce the conflict, and maintain a better balance in such situations.

3.5 Allocations of shares in TACs

Negotiations of shares in TACs and similar decisions on national actions to implement agreed general policies, are essentially political. Biological information, and possibly also biological principles, could help smooth this process, but could not dominate it. A variety of biological information has been suggested - location of spawning or feeding grounds, etc. - that might be taken into account, but the Working Party was unsure to what extent these could, or should, be developed into biological principles. Tentative discussions suggested that principles might be developed based on the extent to which fish exploited by country A were at one stage or another dependent on conditions in the EEZ of country B, and could be seriously affected by the activities of country B. For example, the existence of salmon stocks largely depend on the extent to which the country in whose rivers and lakes they spawn abstain from actions (logging, insecticide spraying, or dam construction) that would damage the spawning grounds or takes positive action to enhance the stock. It was felt that further action by the group after the session might produce some principles that could be of general value. This might be part of a general study of the implications of the establishment of EEZs (see Section 6.1). Apart from the questions of principle, clear advice is needed on the effects of actual or projected activities in one area on the availability of fish in other areas.

A distinction should be made between national quotas, i.e., how much should be taken by the fleets of a given country, and the amount that can be taken in the EEZ of that country. There are obvious political advantages if a country takes all its allocation in its own zone. However, these may be outweighed in some situations, where there are advantages in a country being able to take part of its allocation in other EEZs. For example, a migratory stock may be present in one EEZ for only a few months, and the ability to follow it in other EEZs could enable each country to maintain a round-the-year fishery. Again, the fish in one EEZ may be predominantly small and immature, and there would be advantages to all participants if that country took at least part of its allocaton in other EEZs where the fish were bigger.

3.6 Enforcement

It was noted that shared stocks raised a special problem related to enforcement. By heavily fishing a shared stock within its own EEZ, country A could significantly reduce the amount of the stock available in the EEZ of country B. Country B would, therefore,have a close interest in knowing to what extent any bilateral management agreement concerning stock was being fulfilled by country A. Questions of sovereignty preclude any enforcement of management measure by country B in the EEZ of country A. However, it would be desirable for country B, and especially its fishermen, to be reasonably satisfied with the system of enforcement applied by A to its own fishermen.

In some cases it is possible that biological data can be used to give some check on the degree of enforcement. For example, if young fish are exploited by A, and then migrate into the EEZ of country B, a sudden decline in the abundance of medium fish in B's catches could be an indication of excessive catches by A.

3.7 Associated and dependent species

In principle, given the complexity of the food-webs in the ocean, any fish species in an area can be said to be associated with all other species, and that all higher predators (cod, tuna, etc.) are to some extent dependent on most smaller species. Further, by extension, taking account of the mobility of many species, most species or stocks in one area are to some extent associated with species or stocks in adjacent areas. In practice, most of these links are very weak and are very difficult to determine. The question of associated species only needed consideration in relation to management when there was clear evidence, or a reasonable expectation, that fishing on one species or stock would have significant effects on another stock.

3.8 Fisheries outside national jurisdiction

So far as these relate to fisheries on the extensions or fringes of stocks that are mainly fished inside the EEZ of a single country (e.g., on the south-east corner of the Grand Banks) there appears to be no particular problem. The coastal state concerned might be in a position to take a leading role in determining what measures are adopted and implemented.

In the case of stocks undertaking long migrations (e.g., albacore), which may enter into several national EEZs, as well as occurring outside any EEZ, and in the case of less mobile stocks occurring outside EEZs, the current situation resembles the situation of many high-seas fisheries before the introduction of EEZs. The problem of effectively managing these stocks was by-and-large unresolved, and there seems no immediate answer in respect of these stocks.

3.9 Regional fishery bodies

These could have a number of different roles in respect of management - for example, purely concerned with provision of scientific advice (e.g., ICES); also providing a forum for discussions of principles and problems of management, and actually making recommendations for specific management measures. The establishment of EEZs has diminished the need for the third role; little is now left of the earlier management functions in the North Atlantic of NEAFC and ICNAF. The exceptions are fisheries outside EEZs and, to some extent, shared stocks, though in the latter case the countries concerned may form a much smaller group than the full membership of the regional body. On the other hand, establishment of EEZs, by increasing the opportunities and responsibilities of national governments, has also increased the need by these governments for a forum in their regions in which they can discuss these problems, and by exchanging views and experience obtain guidance on how best to proceed. The FAO regional bodies have a particularly important role in this.

The first role - of providing scientific and similar advice - is, and seems likely to remain, the largest role for regional bodies; they can provide a central data store (especially when several countries are exploiting the same stock) as well as the opportunity for "peer review" when making and reviewing analyses of the state of the resources and the effects (including, if possible, the economic and social effects) of different management action. The increasing demands for advice suggest that the activities of this kind will increase, and hence there will almost certainly be the need for strengthening

of the secretariats of most regional bodies which should, as far as possible, be located in the regions they serve. The scientific work of regional bodies can also include the provision of advice or guidelines on such matters as standard methods of data collection and compilation (e.g., in relation to statistics or monitoring surveys) and on the exchange of data between countries.

Regional bodies, within the general role of providing a forum for discussions on management problems, can also act, to a greater or lesser degree, as an arbitrator between different parties, e.g., on the interpretation of scientific data in relation to setting the levels of the total allowable catch, or to its allocation between countries.

4. Concepts, Principles and Definitions

4.1 The nature of the problem

As indicated earlier, an important obstacle to effective management is poor communication between the different actors (biologists, economists, administrators, and investors) in the management process. Some of this is due to the lack of appropriate institutional links among the actors (see Section 2.3). Another cause of poor communications is the fact that there are few clear and agreed upon definitions of the terms used in management, and that many terms - e.g., MSY - originally put forward in a specific biological or other framework, had taken on new interpretations not intended by their authors, and are used by different people in quite different ways. It was noted at the beginning of the meeting that there were perceptible difficulties in members of the group with different backgrounds communicating with each other because of varying interpretation of terms which individual members thought had quite clear meanings.

It would be quite beyond the capacities of a single group or single meeting to clear up all the uncertainties of definitions and usage. In many cases it would be impossible to agree on a single definition of a particular term. Similarly it would be difficult to achieve definitions of principles that might be followed in fishery management. Attempts have been made to set out basic principles, but these have in general been more successful in illustrating the difficulties of reaching unique and widely applicable principles than in providing practicable guidelines. Accordingly the Working Party concentrated on listing some of the more widely used - and often widely misused - terms, especially those used by laymen in relation to discussions within the U.N. Conference on the Law of the Sea and elsewhere, and commenting on the uncertainties and misinterpretations that have arisen in relation to these terms. Only for a minority of terms have specific simple-language definitions been attempted. It was stressed that the listings and definitions provided here were prepared in a limited time and are to be considered tentative. There might be value in a more comprehensive and authoritative glossary (see Section 6.7).

4.2 Scientific-biological concepts

Model: Fisheries models are generally narrative, graphical, or mathematical descriptions of processes, relationships, systems or concepts. The most common fishery models are graphical descriptions relating: (1) population (or stock) size to surplus production from which theoretical yield values are projected, (2) spawning stock size to expected recruitment - also used to consider yield potentials, (3) growth and natural mortality to potential yields at various fishing mortality rates (F) and size or age at entry,

(4) economic yields to fishing costs at various stock sizes using the logistic descriptions of population growth at various sizes, and (5) the flow of biological material through food chains or trophic levels. In most instances the geometric descriptions are attempts to provide an easily grasped mental image of more complex mathematical relations. The models have frequently been developed by scholars as a mechanism to explain and simplify a concept or theory and as a teaching tool. They have been used by management biologists to gauge or reference the status of exploited stocks. Over time many of the identified reference points of the models have been used to establish harvest strategies, conservation principles and economic principles regarding fishery management frequently ignoring the underlying model assumptions and their limitations. There has been apparent lack of effort to integrate biological, economic and social fishery strategies into a more comprehensive model.

Population, Stock: The terms population, subpopulation, stock, and unit stock are used in a variety of ways in the fisheries literature, often with little regard to population biology or genetics. As working definitions, the following have been employed:

(a) Population: All individuals of a certain species inhabiting a specified region.

(b) Subpopulation: Subset of a population which comprises self-sustaining genetic unit.

(c) Stock: The exploitable group of fish of the same species existing in a particular area at a particular time.

(d) Unit stock: Is often identified in terms of distribution, exploitation pattern, and often implies a self-sustaining genetic entity or entities.

"Stock" is often used to imply varying and different degrees of discreteness as measured by direct genetic evidence, differences in spawning area and season, migratory routes, meristic and morphometric data, growth rate characteristics, year-class strength, and other individual or group characteristics. The complexity of the possibilities in light of this array of potential stratifications indicates the difficulty of recording clear, concise, general interpretations of the term "stock".

The fishery management and research communities should make every effort to describe as well as possible their intentions when utilizing these or other descriptive terms referring to subsets of specific resources.

Fishing Effort, Fishing Mortality: The annual relative rate of decline of numbers in year class of a fished stock has two components: the annual instantaneous rate of fishing mortality (F) and the annual instantaneous rate of natural mortality (M). The rate of fishing mortality is the product of the amount of fishing effort per unit time and the catchability coefficient (q).

Various definitions of fishing effort have appeared in the literature. Biologists typically define an index of fishing mortality (days fished, hours fished, traps hauled, etc.) whereas economists typically define an index of economic inputs (number of vessels, total fleet gross tonnage, etc.). Nominal fishing effort is frequently standardized by

intercalibration to eliminate the effects of systematic differences in fishing power between vessels. The catchability coefficient (q) may vary over time and inversely to stock size, especially in schooling pelagic species.

Catch rates are, in practice, highly variable between vessels, seasons, and nearby areas for the same stock. Thus, control over fishing effort, however defined, can influence the rate of fishing mortality but may not provide precise control over it.

Overfishing: Overfishing means fishing more intensely (higher fishing mortality, or fishing effort) than some desirable level. It is therefore meaningful or definable only after this desirable level has been defined. This can be done in economic or biological terms (for example, MEY or MSY). In biological terms a distinction has been made between "growth overfishing" (in which the yield per recruit is lower than could be obtained at some lower level of fishing mortality), and "recruitment overfishing" (in which the spawning stock has been reduced to a level at which the average recruitment is significantly reduced). It may be noted that it is often not easy to determine when "recruitment overfishing" is occurring until it has become serious.

Depleted stock: A stock (or population) may be said to be depleted when it is suffering from "recruitment overfishing". Since the degree of recruitment overfishing can vary, depending on the extent to which recruitment has been affected, and its existence is not always easy to demonstrate, the practical determination of whether or not a particular stock is "depleted" can be difficult. The classification of stocks as being "depleted" or "not depleted" as a rigid guide to the application, or otherwise, of severe management measures (e.g., a moratorium on all catches) has therefore led, in some instances, to practical and political difficulties.

In the popular literature, "depleted" is sometimes used merely to refer to a stock which is noticeably below the original pre-exploitation level, but this interpretation is not appropriate to fishery management.

By-Catch: "By-Catch" is a term which is used to identify the catch of a species or stock of fish which was not the intended catch of fishermen - that is a catch taken incidentally during the capture of a species of specific interest to the fishermen, e.g., the catch of small and mixed species of fishes during shrimp fishing or the capture of porpoises in yellowfin tuna fishing. Frequently, however, a species may fall into a by-catch category as a result of conservation or economic measures taken by regulatory bodies. Examples include the prohibition of harvest of halibut, crabs, or salmon by trawlers which frequently harvest a complex of species. Finally, by-catch has been used simply to categorize species which comprise the smaller quantities in a mixed catch, thus there appear to be several classes of "by-catch":

1. Species taken which were both unwanted and not the intent of the fishing activity.
2. Species taken by the fishermen which have value but cannot be landed because of regulatory measures.
3. Species taken which were of interest to the fishermen but not of appropriate size or sex, etc.

4. Species which are infrequent, or do not dominate, in mixed catches, but are desirable in terms of market opportunities.

The use of the term "by-catch" for species taken which were not the interest of the fishing activity implies some prior knowledge of intent, and hence may be difficult to determine. More often than not such a classification will lead to the smaller catches in a heterogeneous catch being identified as "by-catch" even though at times such species may have been the target species.

Highly-Migratory Species: The LOS negotiating text lists certain species which are claimed by definition to be highly-migratory species. This may be the best approach for practical purposes, even though some of the listed species are not very highly migratory, while other species are known which undergo greater distance movements than those presently listed. Furthermore, in many cases certain substocks of a given species will be highly migratory, whereas other substocks will be less so.

Common, or Shared Resources: The concept of shared or common resources has emerged over the past decade largely as a result of discussions concerned with extended national jurisdiction and the "Exclusive Economic Zone" (EEZ). The Informal Composite Negotiating Text of the Third U.N. Conference on the Law of the Sea states that where the same stock or stocks of associated species occur within the EEZ of two or more coastal states those states "shall seek either directly or through appropriate subregional or regional organizations to agree upon the measures necessary to coordinate and ensure the conservation and development of such stocks without prejudice to other provisions of this part of the present convention". The practical problem is that under the present LOS text each coastal state establishes the allowable catch for a fishery resource occurring within its EEZ which theoretically could lead to a total allowable catch for that resource well in excess of the MSY or other desired target. There is no clear definition of "shared stock". In one sense a shared stock might be considered a stock which the adult or exploitable portion of the population, moved freely between two or more EEZs. On the other hand a shared stock might also be identified as a stock where the juveniles may live in one EEZ and the adults in another. The LOS text does not make a distinction between life history stages and/or stock availability to the fishermen. A shared stock would appear to be any stock which an action of one coastal state in its EEZ could influence some attribute of the stock in another EEZ (see Section 3). Such a definition would include fishing actions and modifications of the habitat.

4.3 Economic-social concepts

Economic Yield: This term refers to net economic revenue (value of fish caught less cost of fishing) per annum; the term is often taken to be synonymous with "economic rent". There can be severe practical difficulties in defining and identifying both revenues and costs. For example, revenue may refer to dockside receipts, or may include benefits accruing to the processing and distributing sectors. Costs may be equally difficult to specify and quantify.

Fishermen's, or Vessel Quotas: A method for establishing property rights for fishing resources shared among fishermen. (National quotas have a corresponding connotation; see Allocation of TAC). Quotas may be transferrable or otherwise. Unlike total catch quotas,

fishermen's quotas have the potential for minimizing over-capacity. However, there may be severe problems in enforcement, in allocation of quotas among prospective fishermen, and arising from variation in catch-per-unit-effort.

Common-Property Resource: A resource stock that is subject to exploitation by numerous competing agents, usually synonymous with "open-access resource". Most fishery stocks fall in this category. It is a general principle of resource economics that common-property resources tend to be over-exploited, in a wasteful fashion.

Exclusive Rights: Ideally, exclusive rights in a resource stock become established when jurisdiction over the resource is vested in a single owner. Although this situation will seldom occur in the case of fishery resources, various methods exist that may act as proxies or substitutes for exclusive rights. These include: fishermen or vessel quotas, total catch allocations, and economic instruments such as catch royalties or tax charges. Exclusive rights to the purchase of fish (i.e., monopsony) may also serve as an effective proxy, but this has distributional implications that are usually inimical to the interests of fishermen.

It should be noted that extended fisheries jurisdiction, which establishes coastal states' rights to those fishery resources permanently included within the 200-mile zone, does not constitute a complete form of exclusive rights as here defined, except in cases where the fishing automatically falls under the control of a nationalized industry.

4.4 Management and administrative concepts

Sustainable benefits of fishing: The term "sustainable benefit" is used in the context of particular management objectives listed below. It represents the potential benefit that can be taken from a stock in perpetuity in relation to an objective but it is important to realize it is not constant. Benefits may fluctuate from year to year owing to variations in the structure of the stock, and they may fluctuate over a longer time scale as stocks respond to environmental influence. Furthermore, the term "sustainable" implies that the stock is in equilibrium with a given level of exploitation so there will be a time lag in adjusting a fishery from one level to another which may involve benefits temporarily greater, or less than those expected under a new regime depending on the direction of the change.

Optimal Economic Yield (OEY); Optimal Sustainable Yield (OSY) are the sustained benefits that can be taken in relation to a chosen objective whether it be defined in biological or economic terms. These terms are left vague here because no precise definition can be made until the criteria have been established on which the achievement of the optimum can be judged. In its biological (catch) context any OSY will by definition be less than or equal to MSY in order to avoid the consequences of recruitment overfishing.

Maximum Sustainable Yield (MSY) is the maximum average catch that can be taken from a stock (subject to the qualifications outlined above). It is a useful conceptual reference point describing the maximum potential productivity of a stock in terms of catch and is usually associated with an exploitation rate F_{MSY} required to hold the stock at that level of productivity.

Maximum Economic Yield (MEY) is the economic analogue of MSY. It will occur at a different level of stock and exploitation which is dependent on the economic criteria and factors included in the definition of the economic objective. Both OEY and MEY will usually occur at a level of stock biomass greater than that associated with MSY (or at a level of fishing less than F_{MSY}). However, it must be pointed out that controls which aim merely at attaining the level of catch or effort associated with OEY or MEY will usually fail to produce the intended benefit because they will often induce uneconomic reactions on the part of fishermen (see Common Property Resources; Exclusive Rights).

Safe Biological Yield (SBY): Major fluctuations in stock size resulting from interactions between stocks, or unpredicted environmental fluctuations may make it difficult to estimate the level of benefit or yield associated with any of the above objectives in a particular year. This uncertainty can lead to a level of exploitation which inadvertently exceeds the level associated with the desired objective and, in the biological context, may lead to a rapid and potentially serious decline in the stock (see recruitment overfishing) before it can be detected. In these circumstances it will be appropriate to establish a safety factor to allow for the margin of uncertainty and define a potential benefit at a level below the theoretical objective.

Allowable Catch; Total Allowable Catch (TAC): The allowable catch is that quantity that can be taken from a stock of fish resources during some forthcoming periods, normally a year, in order to achieve a given objective. The determination of the allowable catch should therefore be the conclusion of two distinct steps - a policy decision on what specific objective is to be pursued, and the determination, from the available scientific information about the stock, of the magnitude of the catch to be taken in the forthcoming period corresponding to that objective. It should be noted that the allowable catch is determined from what is estimated to be the current state of the stock, so that given the fluctuations that occur in the stock from natural or other causes, the allowable catch corresponding to a given objective is likely to vary from year to year. It can also change as a result of changing estimates of the state of the stock. Also different objectives, e.g., to rebuild a depleted stock quickly or slowly or to harvest at the level corresponding to MSY rather than at maximum economic yield, can result in very different allowable catches in particular years.

Where more than one fishery, or more than one country exploits a stock, the allowable catch must be determined for the stock as a whole. This need is often emphasized by referring to the total allowable catch, or TAC. If allowable catches are determined independently by each country, it is highly unlikely that they will achieve the desired objectives.

Allocation of TAC: Limitation of the actual catch to the Total Allowable Catch can be achieved by one or two methods: (a) fishery closure, and (b) allocation. In the first method, all participating fishermen are permitted to fish until the TAC has been taken, at which point the fishery is closed. In the second method, each participating nation (or each participating vessel) is allotted a fixed proportion of the TAC, which may be captured at any time during the fishing season or at any time specified. The second method has the potential for spreading the catch out over the season, thereby eliminating wasteful effort and excess capacity of both vessels and processing facilities. (See also Fishermen's Quotas).

Surplus Catch: If the current catch from a stock is less than the sustained catch that could be taken from that stock, the difference is in some sense a "surplus" that can be taken by additional fishing. It might be defined as the difference between the allowable catch (or TAC) and the expected catch by the current fishery. Since the value of the TAC depends on objective chosen, neither the TAC nor the surplus catch can be uniquely defined.

It must be emphasized that if a "surplus catch" as defined here exists, this does not mean that such a surplus can be harvested without some effect, possibly severe, on the existing fishery. This is particularly true if the basis for determining the allowable catch has been the achievement of the maximum sustainable yield. For most stocks, any additional fishing will reduce the catch-per-unit-effort, and hence the catch, of the existing fishery. Therefore, if the total effort is increased so as to catch the TAC, the catch of the additional fishery will not be equal to the "surplus", but will be greater than it by the amount of the reduction in the catch of the existing fishery.

Ecosystem Management: The term "ecosystem management" has been used to describe management decisions which involve a broad awareness of the consequences of fishing or other human actions to an ecosystem. In particular it has been used to infer the necessity of understanding multispecies interactions and questions of altered structure of the biological community (ecosystem stability). The management implication of the term "ecosystem management" presumes a reasonable understanding of the physical and chemical environment and the biological species which describe an ecosystem plus an understanding of the interactions among and between the species complex as well as their environment. Effective ecosystem management would also require an understanding of the flow of material energy and nutrients within the ecosystem. At present the totality of interactions is not sufficiently understood in any marine ecosystem to allow for a comprehensive ecosystem management. However, attempts are underway to broaden the understanding of the potential consequence of exploitation on one to more species with respect to other important biological constituents of the ecosystem.

Evaluation of Management: Concerns actions taken to compare estimated and expected performance levels with those actually attained; also relates to the assignment of responsibility and positive or negative sanction.

A variety of different actions exist and could be used, depending on the purposes of the evaluation and resources available. Evaluation may be simple and routine, as is the case of personnel assessments, or complex and extraordinary as with a court ordered board of enquiry.

Decision-Maker: Anyone (individuals/collectivities; public/private) capable of defining, creating, and/or altering elements of the man-fish system. In this sense, the decisions taken may be several stages removed from the site directly affected, e.g., setting trade policies or they may be directly linked, e.g., quota setting.

Policy-Maker: One who formulates a strategic plan, often including explicit statements of general goals and objectives and less often outlining principles of operation.

Fishery Manager: One responsible for the creation and execution of tactical or programmatic means to accomplish policy goals and objectives.

5. Research

5.1 The nature of research activities

Research studies and the data base needed for research or management can be grouped under several headings, but priority accorded to each will depend upon the scale of fishing in the particular country, the scientific and technical manpower available, the institutional capabilities, the funds and facilities available and the aspirations for development of new fisheries or maintenance of existing ones in relation to other industrial and social goals.

Irrespective of whether national fisheries are to be developed or just maintained, there will be a minimal requirement for some basic data. These data will be essential to the formulation of management advice or of strategies for the development or maintenance of the fisheries and the resources upon which they depend.

It should also be noted that there is an obligation on countries which have extended their jurisdiction to manage, for one purpose or another, those resources for which they have assumed responsibility. Where foreign vessels are licensed to fish the zone they will also generate data which the coastal state will need to receive, collate and interpret.

It is in the light of these observations that the research requirements have been grouped.

5.2 Data requirements

Fishery data: Any management system will be dependent upon a minimal data base from which trends in catches or catch-per-unit-effort can be obtained. These data will also provide some measure of the stability of the fishery and a basis for study of the population dynamics of the species being fished. Collection will be almost invariably by governments and as a minimum should include total landings preferably by fishing ground on an annual basis and be capable of being related to type of fishery, fleet and vessel size, with whatever additional measures of catch-per-unit of effort can be obtained. Some of the data will be used simply for monitoring or government recording purposes to show overall production figures, possibly broken down by species or species groups and values. Data for research designed to offer advice on scientific management of the fisheries will need to be much more detailed and may be collected by governments in a form suitable for analysis. In general it can be said that the lack of adequate basic data has been one of the biggest obstacles to a better understanding of what is happening to fish stocks, and to the provision of good scientific advice (see Section 6.2).

Where foreign vessels are licensed to fish the zone there are advantages in having information from more than one country. This allows the coastal state to treat the data from each quite separately and make its own independent assessment of the state of the resources.

Fisheries research will involve the collection of biological and fisheries data for population modelling, assessment of the size of the resources and their likely responses to fishing. In many developing countries long series of data are not available and a

multiple approach to stock assessment is desirable. This provides a way of cross-checking one estimate of stock size against another. The number of such options that are exercised will depend upon staff availability, funds, scientific and technical manpower, technical facilities and possible outside assistance.

Whatever approach to stock assessment and monitoring is used, the value of time series of consistent data (from catch/effort statistics, surveys, etc.) must be emphasized. Much of fishery research is concerned with relating changes in stock abundance, or other characteristics of the stock, to changes in the amount of fishing or other factors. To do this it is essential that the basic data are comparable from year to year.

Catch-per-unit of effort data are essential but other options could include age frequency data (to determine mortality coefficients and stock stability), acoustic surveys, egg and larval surveys, tagging studies (for abundance, distribution and stock identification), estimates of standing stocks from trawl surveys,etc. The practicability of undertaking any of these studies will require some assessment of relative costs and will vary from country to country.

Particularly in the case of surface schooling species or long-lining there are limitations to the use of c.p.u.e. for stock size estimations and other indicators such as distribution of fishing effort in time and space need to be considered. Where countries are using aerial surveillance as an enforcement measure spotting of surface shoals can provide a useful technique for stock assessment.

Biological data: Basic data should include age/length relationships, behaviour (including migration of common stocks), species interactions, influence of habitat, prey/predator relationships, competition, availability of food, etc., etc. In the case of biological data on life histories, growth, spawning behaviour, etc., academic institutes may be able to assist, either independently or via government contract. However, these data will be essential to the government agency charged with offering scientific advice on management.

It is particularly important to note that where stocks are shared by more than one jurisdiction, the biological and fisheries data should be complementary and that in the latter case should be collected according to a standard format capable of being used or interpreted by either party.

Additional research data: use of research vessels: Research vessels are expensive to operate and their cost effectiveness needs to be kept under review. In many instances limited biological and numerical data can be collected by observers aboard commercial craft or by sampling the landed catches. However, for stock assessment purposes the lack of ability to direct fishing operations can result in biased estimates of stock size. Furthermore, changes in fishing patterns can preclude the establishment of meaningful time-series of data which would otherwise show trends in biomass, species composition, age structure of stocks, etc. All of these are essential if any predictive capability is to be developed and research vessel surveys are virtually the only way of establishing a continuity of standard observations. Other studies, for example on mesh selection for estimations of optimum size at harvest, are best conducted from research vessels unless suitable charters can be negotiated.

Joint research cruises, or complementary cruises where stocks occur in more than one jurisdiction, present some opportunity for cost saving and an opportunity for scientific exchange.

Oceanographic data: The Working Party did not discuss the needs for oceanographic data except in a very superficial manner. It is obvious that biological research into the dynamics of fish stocks cannot proceed in complete isolation from the study of the environment in which the fish live. At the same time the cases where it has been found possible to use oceanographic data in one or other part of the overall management process have been few. Where fishery research funds are limited, collection of oceanographic data will probably have to receive low priority, and to be concentrated on aspects that are clearly relevant. It may be noted that oceanographic data are often collected for non-fishery reasons, e.g., for weather and climatic studies, and fishery scientists should take advantage of this material.

5.3 Analysis of data

Models: General considerations: Mathematical models represent formal statements of relationships between concepts and the construction of models is an essential part of the analysis of data. Modelling involves abstraction of a limited number of relevant factors and linking them together. The estimation of the form and parameters of relationships between factors is never perfect and translates into imperfect predictions from models. Neglecting important factors in analysis limits the validity of a model as a representation of reality. Models can deal with the part or the whole of a complex system. The discussions of the Working Party concerning models concentrated on describing a qualitative model of the whole management system (see Section 2.3). Less attention was paid to existing models of particular elements of the system, though these, especially models of the dynamics of fish populations, have up to the present been the main application of models to fishery management. The Working Party did reach some general conclusions, but also felt that modelling deserved rather more detailed examination (see Section 6.5). The further studies should take account of the different classes of models, and the various uses, such as those mentioned below, and the use of models in formulating policy and recommending institutional arrangements.

Biological models: Mathematical models have been constructed and used to predict one or two years ahead the effects of different levels and patterns of fishing mortality on catch-per-unit-effort and on catch from a single stock and on bycatches. At present, such models are not capable of long-term prediction due to lack of knowledge and predictability of recruitment mechanisms and the propagation of errors of information and effects of factors excluded from the analysis.

Models incorporating species interactions have been formulated to examine the implications of such interactions on stock dynamics. Their use has been limited by lack of knowledge of the form and parameters of the interactions. It is presently feasible only to allow for direct interactions such as predation.

Few attempts have been made to include the effects of habitat on a fish stock outside the area of aquaculture.

Biological modelling has been limited by lack of knowledge of relationships. The inclusion of poorly defined relationships in models has facilitated advocacy of special interests. General production models have proven more useful in tropical demersal applications than age structured single-species models.

Bio-economic models: Modelling has concentrated on the comparison of steady state situations as a basis for policy decisions. At present models in this area are not predictive and are not often used to forecast the consequences of alternative management strategies. Although net economic benefit is often defined as profit, this is not universally accepted.

Investment models: While the Working Party is aware that financial models are sometimes used to evaluate investment decisions, no specific examples were identified. Over-investment on the Mexican shrimp fishery was cited as an example of failure of investment analysis to allow for the effect of additional fishing on catch rates of fishermen.

Problems of coastal states: A coastal state can benefit from the resources under its control either by way of licence fees (or similar arrangements with fishing fleets of a foreign country) or from its own endeavours in exploiting the resource. In either case it needs advice on the state of the stocks. Often the most important source of data, and of scientific analysis on which to base that advice is the foreign country, which often has a much larger and more sophisticated scientific capacity than the coastal state. In such a situation the coastal state may wish to reduce its dependence by giving priority to building up its own capacities in stock assessment and data interpretation. Pending this, it may wish to have advice from and have the data evaluated by some independent agency or consultant.

Theoretical problems: Much of the analysis involved in providing scientific advice on fishery management can proceed along well-established lines, using one or other well-known model. There are a number of problems, e.g., in multispecies fisheries or concerning the relation of average recruitment to parent stock, where the way to proceed is not so obvious. The Working Party did not consider these problems, except to note that these represented fundamental theoretical problems which needed urgent attention. It was felt that possibly there was not sufficient research effort being directed to tackling them (see Section 6.3).

5.4 Research policy

How is scientific advice provided?

This is seen as of major significance. There are a considerable number of agencies involved in the fishery management decision-making process in most countries. At the same time there is a need to plan for development (or retrenchment) and to control investment which, if undirected or uncoordinated, can have undesirable consequences for industry. It is a common experience to find that, either the basic scientific advice on stock status and fisheries trends is not 'correctly' proferred or its importance in the eyes of administrators and decision-makers is not fully comprehended by the time it has filtered through several other agencies. Similarly results of economic research may be treated or considered independently. Therefore there is a need to critically review the whole communications procedure and possibly to formulate and formalize for decision-makers those critical questions for which they should be seeking answers. A manual of "guidelines" for decision-makers may be of help in this respect (see Section 6.8).

The timing of advice is vital. It is much easier to make an accurate evaluation of what has been happening to the stocks in the past, and what the effects of past levels of fishing effort have been than to determine the current situation, let alone predict future events. Nevertheless, it must be stressed that the chief value of scientific advice is in taking current decisions, and hence in influencing future events. It must be recognized that the whole process of data collection, scientific analysis and policy decision and implementation is very long, and there can easily be a gap of several years between the time of original data collection, and the time at which the decisions taken are having an effect on the fishery. This delay, which is particularly long in the case of investment in new vessels, combined with the fact that in many fisheries there is a general trend of increasing effort and decreasing catch-per-unit-effort, helps explain why so many investment and other decisions are made on the basis of an over-optimistic view of likely catch rates. The time lags involved in analyzing the scientific data, and acting on the resultant advice should therefore be reduced to the greatest extent possible. At the same time some delays are inevitable, and the advice given should, as far as possible, take these delays into account, and be expressed in terms of the likely condition of the stock at the time that the decisions to be taken are likely to take effect.

It is important that the scientific advice offered does not appear to be prejudiced in one way or another - for example, to give a consistently conservative view of the state of the stock. At the same time there is an important lack of symmetry in taking action on estimates of the state of the stocks which are in error in one direction or another. As a generalization it is economically much worse to be over-optimistic rather than conservative where fisheries are concerned. There is a tremendous difference between lost opportunity and actually making a loss. Also it is much more important to be approximately right than precisely wrong. These differences should be pointed out very clearly in the scientific advice which should emphasize the advantages in taking the more conservative decision, without pre-empting the duty of the administrators to take this political and economic decision.

Within country conflicts

In many fisheries, particularly in inland waters, though also in the ocean, there are conflicts of interests between different groups, and management involves making trade-offs between artisanal fishermen, aquaculture, agriculture, recreational fishermen and other water users, industry and other land users. Apart from the competition for space and facilities, there is also likely to be pollution from industrial and agricultural developments. This can have two effects. First a direct mortality of the fish or on the capacity of their habitat to sustain them. Second, the accumulation of trace elements and other chemicals in the tissues. In this latter case the export marketability of the product may be seriously affected; in both cases some research will be required.

The various interests and problems that may be created will be weighed at the political, decision-making level, but the questions to be asked of fisheries scientists and economists need to be clearly enunciated so that studies can be oriented appropriately. By setting out the questions both the fisheries personnel and the decision-makers may more clearly identify the issues and avoid ignoring those of major significance.

Costs

Costs of enforcing management regulations, of surveillance, of research and of investment in management may be considerable. Not all costs can be readily identified but some assessment of fisheries costs in relation to the value of the industry may assist both developing and developed countries to accord appropriate priorities for allocation of funds and services for fisheries in relation to other industrial and social demands for support. In this context it is also important to note that unplanned incentive schemes or wrong investment by financial institutions can have a serious and adverse effect not only on the fisheries themselves but also associated supporting industries.

Training

There is a need for additional training in fisheries science both in the field of stock assessment and in fisheries economics. There is a world-wide shortage of appropriately trained scientists, economists and decision-makers and a great need for more training at all levels. Few countries have facilities for formal training in fisheries science and though FAO does run fisheries training courses, the total numbers of courses and total numbers of trainee graduates are still very small in relation to demand. Therefore there is a need to investigate ways of raising the overall level of expertise in this field, as well as making sure that trainees receive training appropriate to the ecological and other conditions of their home country.

Apart from training new entrants, there is also a need for retraining with newer techniques and either via training courses or workshops a need for a thorough re-evaluation of some of the models and techniques currently in use.

Post-harvest technology and market research

Any proposals for the development of new fisheries or the expansion of existing ones must, as a prerequisite, contain a technological and market research component. This is particularly the case in respect of the growing number of stocks which are close to full exploitation. Increasing the gross benefits from these resources can be increased only by making better use of a limited catch. Irrespective of the type or size of the resource it cannot be fully utilized unless markets are available and the technology and infrastructure exist which will ensure that the fish, which are highly perishable, are presented to the consumer in an acceptable form. Also and particularly in the case of developing countries, it is most important to recognize that the earnings of artisanal fisheries can be substantially increased by raising the quality of the product without actually increasing the catch.

6. Future Activities

The discussions of the Working Party have shown that fisheries have not been well managed, and could be managed so as to give much greater benefits. Many reasons for this have been in existence for a long time, but the establishment of EEZs have brought them into sharper focus, as well as giving rise to new problems and new opportunities for better management. The time available during the meeting did not allow for many of the problems to be examined in more than a cursory manner.

The following questions need further attention:

Are the tools of policy analysis available to administrators to assist them in assessing the political, social and economic factors upon which they must make their decisions?

Is the administrators' concern for information adequately communicated to scientists and technicians?

Does the information produced by scientists match the needs of the administrators?

Is the science that is required for decision-making produced on a reasonably cost-effective basis?

Is the entire process viewed as a process so that each state is ensured that the proper weight is applied to each aspect of the process; so that each problem area is dealt with on a cost-effective basis; and so that the proper problems are addressed?

The Working Party agreed that the complexity of these issues required discussion at a future meeting; and that a number of background studies should be prepared in advance of that meeting. The agenda of the meeting should be structured to make the best use of these studies, which might include the following:

6.1 Consideration of special problems arising out of extension of national jurisdiction

Extended jurisdiction will provide the coastal state the opportunity to promote a number of national objectives but at the same time will create a number of obligations and special problems which are unique to jurisdictional change. Problems associated with enforcements, identification of surplus allowable yield, shared stocks and dependent and associated species, defining national capacity, and allocation of resources between adjacent states are examples. The Working Party felt it important in carrying out its terms of reference to undertake a study of the LOS text concerned with management of living resources as well as examples of national legislation resulting from unilateral extension of jurisdiction and identify the consequences to the management of the resources.

6.2 The data problem

It was generally agreed that fishery management was hampered by data that was often inadequate and not timely. The Working Party agreed that there was a need for something more than a further call for better data, and that for its next meeting a paper should be prepared that would enable the Working Party to make specific, action-oriented proposals that would lead to better data; topics to be covered in such a paper which should take account of existing reviews of the data problem might include:

- costs and benefits of different qualities of data;
- variability;
- time lags in processing and analysis;
- the use and purposes of data;
- responsibilities for collecting and disseminating data;
- the performance of present regional and global data systems.

6.3 The research problem

The Working Party agreed that contemporary management, short of data-poor early warning systems, is faced with critical information problems of multiple-species management, stock fluctuation or stock and recruitment problems, and relating biological and economic criteria. It is not clear to the Working Party the extent to which the national research budgets are focussing on these critical areas. The Working Party recommends an analysis of the extent to which the research fund is focussed on these issues. The analysis should include:

- a review of the important problem areas;
- an analysis of the various approaches to these areas;
- a consideration of the approaches that are likely to afford the highest pay-off;
- a rough view of how effective the national programme taken as a whole might be with respect to focussing on the critical issues;
- guidance with respect to future direction. Appropriate levels of research technology particularly in multiple-species, stock variability, and bio-economic areas.

6.4 Dealing explicitly with variability

The Working Party noted the characteristic variability of many fish stocks and the dis-economies that such variability might induce in economic and social systems. The Working Party recommends an analysis be made, possibly by Mr. Doubleday, of:

- causes of variability;
- methodology for predicting variability and thereby reducing any deleterious effects that it might have;
- methodology for dealing with variability when it occurs such as limitation of effort, insurance programmes, etc.

6.5 Models

The Working Party felt that it would be useful for its next deliberations to prepare a perspective on models. It should contain;

- a discussion of the kinds of models and their uses;
- a catalogue of existing fishery models as well as models that might be taken "off the shelf" from other fields and applied to fisheries;
- an evaluation of selected fishing models with respect to their relevance, utility and application;
- multispecies models;
- examples of new applications of models.

6.6 Communications

The Working Party felt that many apparent difficulties in fishery management are the result of imperfect communication throughout the fishery management system. An analysis is therefore required of the present level and effectiveness of communication, including the following aspects:

- desirable channels of communication;
- techniques to improve communication.

6.7 Glossary of terms and concepts

The Working Party concluded that many terms and concepts were used in fisheries management. Often these terms mean different things to different people. When this happens time is wasted in a preoccupation with the terms and concepts rather than a direct address of the issues. Sometimes various terms obfuscate the most direct conservation and management measures. In order to address the Babelian nature of terms, concepts and principles, the Working Party recommends that a glossary be developed that discusses the many various terms and concepts which are used. This would be of particular benefit to the administrator.

6.8 Guidelines for fishery development

The Working Party felt that information on fishery development, particularly the various decision criteria used in fishery development, is scattered and difficult to access. Material regarding these processes should be developed and a rough draft of the possible set of guidelines to the development processes should be submitted to the next meeting. This might include a checklist of points to be considered at regular intervals, or before important fishery development decisions are made.

6.9 Management methodology

The Working Party felt that new techniques for fishery management needed to be developed. It felt that the traditional "data-rich" decision rules were often not practical for dealing with contemporary management problems. The Working Party suggested a study of:

- the criteria and variables that might be included in data-poor models;
- the nature of "data-poor" models, their costs and benefits;
- early warning systems that might emerge from these or other algorithms.

6.10 Rational bases for management decisions

The Working Party noted that in many world fisheries the current situation regarding capitalization, fishing effort, and the magnitude of the total catch and its distribution was not in some sense optimal. It was felt that this was in some cases due to the lack of clear objectives in managing their fisheries, or the use of inappropriate or conflicting objectives. It was therefore believed that it would be useful to have a listing, and a critical review of objectives used in management theory and practice. This review, which should also consider the effectiveness of various forms of exclusive rights, might include the following aspects:

- behaviour of various bio-economic models;
- theoretical analysis of alternative forms of exclusive rights;
- case studies of existing systems of exclusive rights (entry limitation; fishermen's quotas; etc.);
- what might be learned from experience in the regulation of other common-property resources (groundwater, unitized oil reservoirs, grazing lands, etc.)?

- procedural constraints, including time lags;
- administrative requirements.

6.11 The fishery investment system

The Working Party agreed that excess fishing capacity, and hence excess investment in fisheries, was the proximate cause of many management problems. Many activities have some influence on investment decisions (e.g., national tax authorities, especially as regards re-investment within fisheries, international development banks, etc.). It is not at all clear what entities or groups of entities, have most influence in determining the overall level of investment in a particular fishery, or in fisheries as a whole. In order to make meaningful suggestions as to how investment decisions might be controlled or modified to facilitate better management it would be highly desirable to have a review of the present investment system, and of where the important decisions are reached. This review might include:

- the identification of those responsible for taking decisions affecting investment in fisheries;
- the criteria used in reaching those decisions;
- the difference, if any, between these criteria, and those that might apply in respect of fishery management (e.g., do investors take an unduly narrow view);
- the relative importance of different sources of investment;
- time lags in the process of reaching investment decisions that could invalidate the decisions.

6.12 The decision system

Successes and failures in fishery management are often based on a long series of sequential decisions. Furthermore, the actors in the decision process are not always evident. In order to diagnose problems in the decision system which for many fisheries is obscure, the Working Party needs for selected fisheries:

- an analysis of all the actors in the decision process;
- the degree to which the same information is available to all the actors;
- the distribution of weight in the decision process for the various actors;
- the way in which these variables change as a function of the decision structure and time.

These studies should take particular account of the actual and potential role of regional fishery bodies in these processes.

6.13 The development of a fishery management institute

Under the complexities of EEZ it is essential to relate the many diverse biological, economic and social components of the decision process to one another so that a high probability of making good decisions is ensured. The procedural management questions associated with communication, planning and control are as important as the required multi-disciplinary substantive knowledge. The Working Party felt that it would be helpful to develop an institution which would train a cadre of managers. The formation of such an institution needs to be studied in the intersession according to the material outlined in Appendix 3.

Priorities

The Working Party did not attempt a complete ranking of priorities, but felt that studies of the impact of extended jurisdiction (6.1), the research problem (6.3), questions of communication (6.6), the processes involved in reaching various relevant decisions (6.10, 6.11 and 6.12) and the possible establishment of an Institute of Fishery Management (6.13) deserved particular attention.

7. Interim Conclusions

The Working Party recognized that it had only started on a very large and complex task. Therefore it was too early to put forward extensive and detailed conclusions. There were some general points which emerged clearly from these early discussions, and which deserved wider attention:

(i) The establishment of EEZs provides opportunities for better management, but these opportunities will disappear if they are not attended to urgently.

(ii) There is a serious lack of communication between those directly attempting to manage resources, and others taking decisions which have a great impact on the operations of the fishery and the success or otherwise of management schemes (e.g., tax authorities, investors).

(iii) While it is essential to take account of biological factors when managing, if only biological factors are taken into consideration there may be little, if any, economic benefits from the fishery.

APPENDIX 1

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APPENDIX 2

LIST OF DOCUMENTS

A. Mini-papers prepared by members of the Working Party

SCIENTIFIC BASIS FOR DETERMINING MANAGEMENT MEASURES, by B.J. Rothschild

OPTIMIZATION THEORY AND FISHERY MANAGEMENT, by Colin W. Clark

SCIENTIFIC BASIS FOR DETERMINING MANAGEMENT MEASURES - NEW ZEALAND EXPERIENCE, by G. Duncan Waugh

PERSPECTIVE OF FISHERIES MANAGEMENT IN BRAZIL, by S.J.S. de Moura

A BRIEF REVIEW OF THE EVOLUTION OF RESOURCE MANAGEMENT ADVICE IN THE ICNAF AREA 1965-78, by W.G. Doubleday

ASPECTS OF FISHERIES MANAGEMENT IN THE NORTH ATLANTIC, by D.J. Garrod

REPORT ON THE STUDIES OF MULTISPECIES SYSTEMS IN FISHERIES, by V. Hongskul

MANAGING FISHERIES: SOME DESIGN CONSIDERATIONS, by Garry D. Brewer

SOME THOUGHTS ON MANAGEMENT, by H. Kasahara

A GLOBAL PERSPECTIVE ON CONTEMPORARY PROBLEMS IN FISHERY MANAGEMENT, by J.A. Gulland

LETTER from B.B. Parrish

B. Other documents consulted during the meeting

Anderson, L.G., 1978 The necessary components of economic surplus in fisheries economics. Unpublished MS

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APPENDIX 3

AN INSTITUTE OF FISHERY MANAGEMENT

Background

A variety of problems facing the world's fisheries and those who are being relied on to manage these resources were identified and discussed during the course of the Rome meetings of the ACMRR Working Party. Recognition of these problems has resulted in many specific proposals for needed research, additional clarification, and future study and discussion. Without intending to preempt any of these worthwhile efforts, it may be useful to summarize in a general fashion some of the main concerns and then to consider one tangible method of resolution.

The complexity of the fishery management environment is far greater than most have imagined. It is not simply a matter of conducting scientific studies of fish biology or population characteristics and then putting these findings into practice; rather, a full understanding of this system very quickly shows that biological considerations are but one of a veritable constellation of factors that must be understood and taken into account. Decisions made by an economist in some far away development bank to add to the capital infrastructure of a nation having untapped or underexploited fishing resources may be made for all the "right" or superficially rational reasons; however, such decisions may impact on the fishing resource with devastating results. (The instance of some shrimp fisheries was brought to the Working Party's attention in this regard). The problem, simply stated, is that the environment is connected through many non-obvious links, there are many more participants involved than most people realize, and the variety of interests, objectives, and purposes represented by these participants nearly necessarily leads to confusion, conflict, and less than desirable outcomes for the system taken as a whole. (A fuller discussion of this is contained in the paper prepared by G. Brewer in preparation of the Rome meeting: "Managing Resources: Some Design Considerations", and will not be recited here).

Lack of appreciation of the full complexity of the man-fish system and environment - a bearable shortcoming in years past - has become increasingly intolerable as pressure mounts against the fisheries of the world and as nation-states exert their claims to ownership and exclusive control through extended jurisdictions and other devices. For instance, what does a nation do when an over capitalized fishery collapses? What kinds of information might have given some advance warning of *in extremis* collapse in fish stocks in the face of ever increasing amounts of fishing effort? Who should be generating and monitoring this situation; who should be told; and what could and should be done to limit its effects - on stocks of fish and on the lives of fishermen? The fact that most of these and similar questions cannot be very well answered is at least suggestive of one class of management problem that has been ill-attended, but one that demands attention and resolution.

This suggests even more fundamental intellectual and practical issues that require scrutiny. Who, for instance, is a "decision maker?" Is it the research scientist who knows virtually all that there is to know about a specific stock of fish in a given location somewhere in the world? Is it an international official in one of the development agencies? Is it a lawyer immersed in the fine points of negotiation of a bi- or multi-lateral agreement or treaty? Or is it some as yet unidentified individual whose actions have implications for the fishery resource? There is no general answer other than to say that some, all, or none

may be involved in a given setting or context at a specific time. (The Working Party spent a considerable portion of its time in mapping out a list of potential participants, and this kind of exercise certainly needs to be expanded and refined in the future. Furthermore, it was clear to all members of the Working Party that similar "decision studies" ought to be conducted in local, regional, and international management settings to keep uppermost in mind the magnitude of the real difficulties inherent in the question "Who is the decision maker?").

It is reasonably safe to say that there is a large present and probably increasing need to expose and prepare managers for a world having these and other extraordinarily complex features. While the precise approach to be taken is in itself a topic meriting a great deal of attention and thought, the Working Party as a whole was interested in the general proposition of creating an Institute of Fishery Management to begin the task.

The following discussion lays out specific details of what such an Institute might look like, but does so only to stimulate interest and added thought about the matter, not to suggest that this is the best or only way that the tasks might be accomplished. (In fact, one member of the group has been delegated the responsibility of exploring the Institute option in somewhat more detail, taking into account other fishery training programmes and experiences, feasibility, costs, strategies, and a variety of modus operandi).

Purposes to be Accomplished

In the most general terms, such an Institute would be created to provide quality level instruction for the present and emerging cadre of fishery managers throughout the world (the difficult terms "decision maker", "policy maker", and "fishery manager" were all treated and defined by the Working Party and can be found elsewhere in this Report). Additionally, efforts to share an understanding of the complexities of the man-fish system would be made to include both policy makers and key decision makers whose actions bear on the use of fishery resources.

More specifically, Institute participants should be made aware of the full complexity of the economic/political/social decisions that they are likely to be called on to make; the dynamic nature of the fishery resources and their management; and the diversity of participants, interests, actions, and objectives that will be impinging on the man-fish environment or setting.

Additionally, those enrolled in the programmes of the Institute should be introduced to a variety of management tools and techniques that have been and are likely to become essential to the proper discharge of their duties and responsibilities. In this regard, the concept of "most appropriate technology", including management technologies, must be stressed. What, for example, does one need to know about financial and investment theory and practice generally, and how does this knowledge have to be modified to suit the case of the often fragile, unpredictable, and ever-changing fish resource? How does one devise enforcement procedures that work, and do so with a minimum of administrative overhead and headaches? What instruments of control exist, beyond the often unsatisfactory resorts to subsidies, investment incentives, and brute force policing, that would allow the manager to get the best use of his resources over the long haul?

These are difficult questions, many of which have no readily or generally apparent answers; however, it is the considered opinion of the Working Party that their resolution is sufficiently important to justify exploring the construction of an institutional focus.

A Proposal

It is proposed that there be established, perhaps in FAO, Rome or perhaps elsewhere, a six-week basic course of instruction composed of two different parts or "tracks". The first track would be aimed at the needs of policy makers (N.B. consult Working Party definitions and concepts) and would concentrate on subjects such as the practical implications of the UNCLOS and other standard fishing agreements; cases prepared and designed to demonstrate the interconnectedness of the economic/political/social environment; sufficient introductory technical courses to prepare the policy maker to be a good consumer and user of the analyses prepared by scientists and other technical specialists; and scenario-based studies that could portray different strategies for the development of a fishery resource (for instance, rapid development of the indigenous fishing fleet versus licensing of foreign fishermen).

The second track of the basic course might be tailored to the needs of the fishery manager, that is the individual who is called on to implement or carry out the details of the fishery strategy finally adopted. Accordingly, courses in financial management, investments, international law, negotiations, data base generation and management, and methods of management evaluation would be stressed.

Because of the pervasive communication gaps that exist in the current management environment (described and discussed elsewhere in this Report), it is essential that at least the beginning of the basic course should be a shared experience for both policy makers and managers; they would attend classes together.

Both tracks would result in a more common view of the current status of fishery management problems, an opportunity for the creation of standard sets of expectations and ways of treating common problems, and in shared knowledge about the existence of numerous individuals and centres of learning and management throughout the world. (This, of course, is of particular note for the developing fisheries of the world).

In addition to the basic course, specialized, tailor-made courses in each of the management topics treated should be considered. These courses would be held from time to time in individual countries and/or in regions where fishery problems are evident, e.g., a special seminar for investment or development bankers would be conceivable under this scheme. The flexible nature of this phase of the programme should allow the best use of advisory or non-full time personnel in the training, case preparation, and other elements of the programme. This also conforms well with an overall desire (voiced by many members of the Working Party) to keep administrative overheads for any educational programme to a minimum.

Some Potential Outcomes

Hopefully, whatever the eventual form this Institute might take, the general and specific purposes would be realized in sufficient measure to justify the effort. One can imagine other, more specific outcomes for this proposal.

The basic course would be an important source of case study materials concerning the management of natural resources; these cases, once prepared and tested out, could then be made available for use in other management schools and programmes throughout the world. (There seems to be a dearth of such case materials at present; their development and use in general management programmes could help alert other managers to the special situation presented by fishery resource management).

The Institute would also be able to help identify and undertake needed research in the fishery area (this is not meant to place the Institute in a competitive position with other, existing research enterprises; rather, it should be seen as a complement and enrichment of those efforts). The Institute could also assist and work toward the definition and promulgation of standards for data collection and use (a point stressed in the deliberations of the Working Party, e.g., management data are not the same necessarily as scientific ones).

The primary outcome of the Institute would be the generation of a corps of trained fishery managers prepared for deployment throughout the world; these managers represent a different professional speciality than any presently existing; and in time their capabilities should be recognized and valued by policy makers and others throughout the world. In this sense, standardization is encouraged, not forced; and any nation that wishes to participate in the programme to attain the benefits of this professional service and talent may certainly do so.

Next Steps

The Working Party agreed that the general proposition and proposal deserved more detailed consideration; G. Brewer will prepare, in advance of the next meeting, a short paper elaborating several different ways in which the broad objectives might be attained. Presuming that the task is still viewed as being desirable and feasible, the next step could very well be the earmarking of FAO resources for a detailed plan. (One might only guess at what could be involved here, but a level of effort of about six man-months is probably conceivable).

SCIENTIFIC BASIS FOR DETERMINING MANAGEMENT MEASURES

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The extension of fisheries jurisdiction by many coastal states has opened new opportunities for fishery management. The control over the stocks afforded by extended jurisdiction enables the coastal states to utilize management techniques that have been heretofore beyond the scope of their authority.

It is not enough to simply have management authority. This authority must be used wisely for the benefit of the coastal state and those who have a need for the fishery resources, both now and in the future. Thus, we must ask, what are our objectives in fishery management; do these objectives make sense; what is the best way of attaining these objectives; what are the costs and benefits of our management techniques; are there ways to improve the job we are doing?

The answer to these questions lies in the areas of both science and administration (administration is taken here to include both administration of science and administration of fishery management *per se*). Science is the umbrella that covers "what we know" and administration is the umbrella that covers the actions that we take to improve or make our knowledge useful (these actions are, of course, based on "what we know").

It is possible to consider science by itself, but in areas of application it is sometimes necessary to consider both science and administration. If we consider science by itself, we are led into an ethereal world of abstraction, inhabited by hoards of scientists; most scientists are convinced that they are doing the right thing. They continue to wait for an intuitive flash of brilliance. For many, the flash never arrives. On the other hand, when we consider science in the context of application and in juxtaposition with the administrative actions that attempt to improve and effectively utilize science, we are led to criteria that are perhaps new to some; these criteria are excellence and relevance.

Making sure our science is excellent and relevant places us on the horns of a dilemma. On one hand, when we overdirect science, we take the chance of excluding from our considerations important intuitive flashes of brilliance. On the other hand, letting science run free is a prescription for decreasing relevance and excellence. The dilemma is best addressed, I believe, by increasing the proportion of good people working in fisheries and emphasizing that scientists have a social responsibility to help solve management problems.

An efficient solution to doing a better job involves specifying scientific requirements and then developing an environment that promotes the growth of cost-effective procedures for meeting these requirements.

I believe we can begin by specifying the modern fishing management problem as a problem in which a controller, the manager, is faced with an assemblage of fish stocks. These stocks vary in magnitude, growth, mortality, and reproductive success. The paramaters associated with the stocks interact on an inter- and intra-stock basis and vary in time and space. The manager understands only part of this variability. He has a budget, though, and he can use it to pay to understand a greater part of the variability (the manager is inefficient if he does not receive a return in this expenditure). At the same time, the manager is faced with an assemblage of fishing boats. These boats, too, vary. They exert different amounts of fishery mortality per-unit-of-time and their cost of operation varies as well. The manager can control, depending upon the administrative regime, a varying portion of the fishing effort. He must exert control in such a way so as to maximize benefits to society.

What kind of science do we need to accommodate this system and help the manager maximize benefits?

It seems to me that this question involves the fact that:

- We have no cause-and-effect forecast models for stock distribution and abundance.
- We have no synthetic fishery effort models.
- There are few, if any, state-of-the-art management information systems.
- We have no understanding of how pollution at ambient levels affects the population dynamics of fish.
- We have no assessment of the importance of multiple-species management or management that takes into account variability in fish stocks. Further, if these aspects of management are important, we have no way of addressing multiple-species management or the management implications of variability.
- We have not utilized linkages between economic consideration and population-dynamic considerations in management.
- We have not used market and other institutional factors to guide scientific application and the development of fisheries.
- Linkages between fishery developers and managers tend to be minimal.
- On a global basis, we do not have research targets, analysis of research efficiency, or specific programmes to improve fishery research and education.
- There is no specific programme for providing scientific-analysis assistance and institutional-building capability to the coastal states that have an urgent need for this service.
- There is no global plan for fishery research and management.

I suspect that my intention of wanting to prepare a provocative list for our discussion has led me to some overstatement. If so, then we will have an interesting discussion to ameliorate my views.

OPTIMIZATION THEORY AND FISHERY MANAGEMENT

by

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Introduction

The economic theory of commercial fisheries has traditionally been concerned with the problem of economic inefficiency of the common-property fishery, which is then set in contrast with the economic "optimum", or "rent-maximizing" fishery (see Gordon, 1954; Clark, 1976; Anderson, 1977). In practice, however, doubts have been expressed (even by economists) that such an optimum ever would be, or ever could be achieved. Any given bioeconomic model of a fishery is simultaneously over-simplified, in terms of its assumptions and implications, and overly complex, in terms of its data requirements. Consequently the true economic optimum will be forever elusive, if indeed it exists at all. 1/

Nevertheless, economic theory (including optimization theory) has at least two important roles to play in fishery management. First, the existing theory clearly shows that unregulated fisheries will be suboptimal, and indicates that in many cases significant improvements in economic performance can be obtained under appropriate forms of management; this is the "normative" role of the theory. Secondly, by adopting the not unrealistic assumption that individual participants (fishermen, processors, etc.) do attempt to maximize their own net benefits, economic theory can be used to predict the reaction of the fishery, in economic terms, to various forms of regulation; this is the predictive role. However, this second role of economic theory has until now not been exploited in any depth (see Clark, 1979).

In this mini-paper I shall very briefly review the current state of theoretical fishery economics, and discuss the implications that seem to be clearly emerging for the actual management of commercial fisheries, especially with the recent establishment of 200-mile zones (EEZs). In a nutshell, it seems that the theory is only now beginning to reach a stage where it can be of practical value in the design of management policies and institutions. The most important finding, in my view (and this is currently a somewhat controversial topic), is that achievement of satisfactory levels of economic efficiency is probably impossible unless some form of exclusive "property rights" or appropriate substitute, can be established with respect to the fishery resource. In other words, the traditional view of marine fisheries as the "heritage of mankind", freely available to everyone who wishes to exploit them, is no longer tenable under present conditions of demand for fish and the technology of fishing. The establishment of 200-mile zones show clearly that this fact has now become generally recognized, but the problem remains of designing appropriate management institutions and methods for fishery resources within these new zones. In particular, the traditional concepts of fishery management, based on the maximization (or "optimization") of biological yield, will require extensive modification in order to achieve economically based objectives.

1/ "One may be able to optimize a model; one cannot optimize a situation". (Loasby, 1976, p.42).

The Common-Property Fishery

The economic performance of the common-property, or open-access fishery was analyzed in 1954 by H.S. Gordon, who showed (Fig. 1) that the fishery could be expected to achieve a "bionomic equilibrium" at which net economic revenue (economic rent) vanished. The more valuable the catch, relative to the cost of fishing, the greater the resulting level of exploitation and of depletion of the stock. This outcome was contrasted to the rent maximizing level of exploitation, which was identified with the optimal sustained economic yield.

The implications of Gordon's theory for fishery management were discussed in a number of studies published in the 1950's and 1960's (e.g., see Hamlisch, 1962). Although this theory is now seen to be over-simplified in many important respects, it still reflects the basic economic problem of fisheries: unless strictly regulated, effort tends to expand to a level at which net economic benefits to fishermen [2/] are entirely dissipated.

Management Policy

The next logical step in theoretical fishery economics would seem to concern the economic performance of regulated fisheries. Unfortunately, for a variety of reasons this theory has proved to be rather difficult, and results are still fragmentary. It was noted early on, however (e.g., Crutchfield and Zellner, 1963), that the traditional management objective of maximum sustained yield (MSY) had little economic relevance. Economic rent would still be dissipated under an MSY management programme, normally through over-expansion of fishing capacity and a corresponding shortening of the fishing season. Nevertheless, unless over-expansion becomes so extreme that the situation gets out of control (which is a real possibility), the stock protection implied by an MSY management policy at least preserves the option of ultimately introducing some form of economic rationalization. But, as often noted, the social and political problems associated with the reduction of existing excess capacity can be severe.

At present, many fishing nations are experimenting with various programmes of limited entry as a method of controlling capacity in fisheries.[3/] But, while limited entry is admittedly a necessity for economic rationalization of fisheries, it remains doubtful that limited entry by itself will be sufficient for this purpose (for opposing viewpoints, see Clark, 1978, and Crutchfield, 1978). Briefly, if economic rents do begin to emerge in a limited-entry fishery, the competitive tendency underlying the Gordon analysis will tend to evoke a further expansion of fishing power, in whatever forms may remain imperfectly regulated. Thus existing vessels will tend to become replaced by larger, more powerful vessels, surpassing the level of optimal economic efficiency. The ultimate result may be a continued struggle between the authorities, designing ever more complex and detailed regulations, and the fishermen, discovering new methods of by-passing them.

2/ More precisely, to marginal fishermen; above-average fishermen may do very well in a common-property fishery.

3/ In the case of Japan, limited entry is a long established tradition.

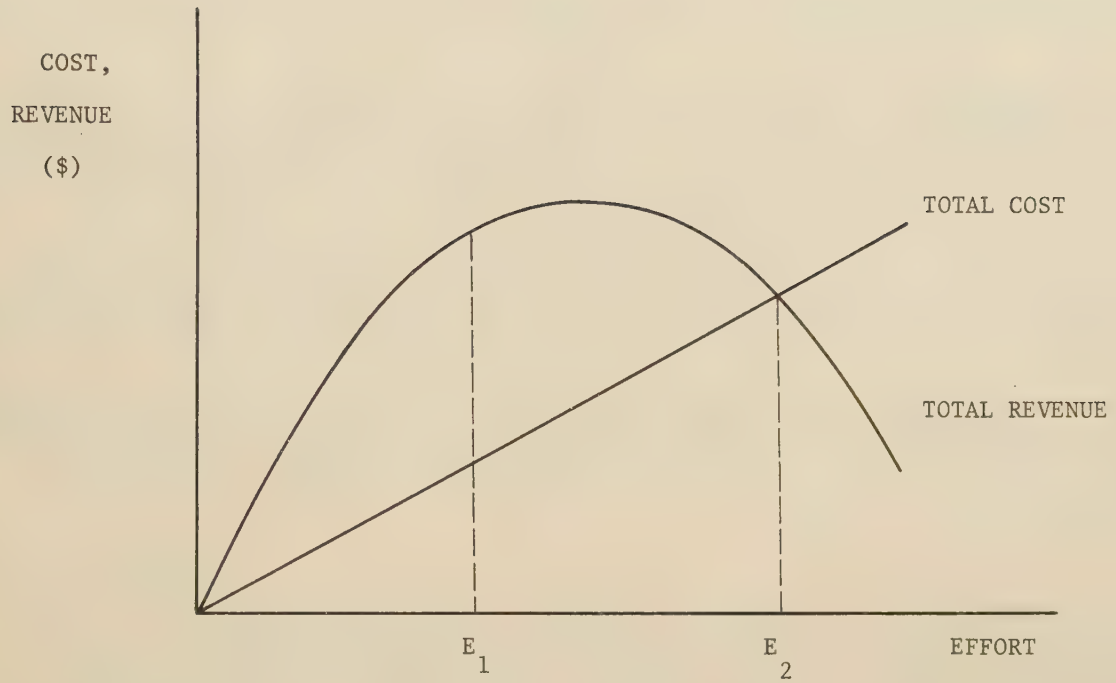

FIGURE 1. H.S. Gordon's (1954) theory of the common-property fishery. In the absence of regulation, effort expands to E_2, where total cost = total revenue, and economic rents are "dissipated." The (zero discount rate) optimum would be at effort level E_1.

An alternative approach (Christy, 1973) involves quota allocations, whereby individual fishermen or vessels possess the right to catch a certain quantity of fish per season. Provided, among other things, that such quotas are transferable among fishermen, it can be demonstrated on theoretical grounds (Clark, 1979) that economic rationalization will be encouraged.

On the international level, total allowable catch (TAC) allocations now have a fairly long history in certain fisheries (e.g., marine mammals, in particular), and are becoming progressively more common as the advantages in terms of controlling undesirable expansion of fishing fleets become recognized. Quota allocations to individual vessels in coastal fisheries are less common, however. An interesting experiment is the system recently instituted in Canada's Bay of Fundy herring fishery. As yet unsubstantiated reports indicate that this system is proving both highly successful economically, and highly acceptable to fishermen.

In general, a quota allocation system would have to be designed with considerable care in order to be both efficient and acceptable. In particular, some method would always be needed to ensure that total quotas were adjustable from season to season, in response to stock fluctuation.

This latter point raises the difficult question of the management of fisheries dependent upon depleted stocks - whatever the original cause of depletion. First it should be emphasized that the social and economic problems associated with stock depletion are likely to be greatly exaggerated under conditions of excess capacity resulting from the absence of economically effective management policies. Conversely, an appropriate programme of entry limitation (in both the harvesting and processing sectors) combined with catch allocations, would make allowances for expected temporary declines in fish stocks.

The really difficult cases arise after the collapse of an important stock, when appropriate controls on capacity have not been achieved during the development of the fishery. It is of utmost importance that persons involved in the development of new fisheries, whether within EEZs or not, be made aware of the dangers of (and the built-in tendencies towards) over-expansion. For example, it has been noted that new fisheries are often initiated on stocks which are at an unusual peak of abundance resulting from exceptional environmental circumstances. Such fisheries may be highly productive initially, but the early catches cannot be sustained. If fishing capacity is permitted to expand beyond the level needed to catch the long-run sustainable yield, the result will be an impoverished fishery, which will render appropriate management all the more difficult.

The importance of basing the development of a fishery upon realistic stock assessment should thus be clear. Unfortunately, such assessments may be difficult to obtain. Nevertheless, it must be emphasized (especially since it has so often been overlooked) that uncontrolled private investment in fishing capacity will almost inevitably proceed far beyond biologically and economically justified levels. In some cases the process has been further intensified by ill-advised development planning, involving ship-building subsidies and so forth.

Distribution of Economic Benefits

If a productive fishery is appropriately managed, for example by means of an allocated quota system, substantial net economic revenues may be generated. The question then arises as to the ultimate recipients of these benefits. First, the benefits may be allowed to pass entirely to the holders of quotas, who thus become essentially the actual owners of the resource. The danger in this, of course, is that these owners may become significantly enriched, which may not appear justified to the public at large - even though similar policies may have been long established in other resource industries.

An alternative approach (also commonly used in other natural resources) is for the government to sell or auction fish quotas, or to impose royalties on landed catch. In this case, the corresponding revenues accrue directly to the public purse. There seems little doubt that these are the methods that will normally be employed in awarding fishing rights to foreign vessels operating within 200-mile zones. It is less clear to what extent governments will insist on a share of the revenues from domestic fisheries.

For a more detailed analysis of quota systems, see Christy (1973), and Clark (1979).

Data and Modelling

The need for reliable and timely biological data has often been emphasized, as has the need for developing appropriate biological models of the resource. For the economic aspects of management, considerable effort should also be devoted to economic data and modelling. Unfortunately, techniques of economic fishery modelling are at present but poorly developed; few reports, and no general guidelines, have been published.[4/] However, for developing fisheries, the most important data are of a biological nature, concerning stock assessment and catch-per-unit-effort projections. Once an allocated quota system has been established, total annual quotas can be adjusted as further knowledge of the stock's productivity becomes available. If necessary, additional licenses can be issued. Under such a quota system, the complexities of economic modelling can be largely ignored, provided that catches are restricted to sustainable levels, and total capacity is not permitted to expand beyond the level needed to capture this yield.

Conclusion

The economic theory of fisheries clearly identifies the common-property aspect as the basis for depletion of fish stocks and for the unsatisfactory economic performance of commercial fisheries. Recent analytical studies support this theory by indicating that some form of restricted and exclusive rights to harvest specific quantities of fish are necessary in order to preserve profitability of fishing. The determination of appropriate quotas requires biological and, to a lesser extent, economic surveys of the fishery. By selling or auctioning quotas, or by imposing catch royalties, the government can ensure that some or all of the economic rent accrues to the public purse.

4/ See Clark and Kirkwood (1979) for a rather detailed bioeconomic model.

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SCIENTIFIC BASIS FOR DETERMINING MANAGEMENT MEASURES - NEW ZEALAND EXPERIENCE

by

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Background

New Zealand has a land area of about 267 800 km^2 but a population of only 3 million. The continental shelf is narrow averaging only 19 km in width but there are extensive plateaux down to about 1 000 m to the west of the North Island and to the east and south of the South Island.

For 20 years prior to 1962 fishing was restricted to licence holders but after the advent of foreign vessels fishing outside the territorial (3 mile) zone in 1959 it was realized that the fishery resources could sustain extra effort and the restrictive licencing system was abandoned. However, there was no knowledge of the size of the resources or of the species which they comprised. In 1965 a fisheries research group was established to undertake this work.

Because the shelf is narrow and because fish are an insignificant part of the national diet there was little incentive to develop a major industry. Boats were small, maximum length 20 m, and seldom worked more than 3 days away from their home port. Surplus fish were exported principally to Australia though the high value rock lobsters, caught close inshore, were sold to the U.S.A. The post 1962 expansion has, therefore, been export oriented.

The first work of the Fisheries Research Division was aimed at understanding the biology of the principal commercial species of fish and shellfish most of which are peculiar to New Zealand or to Australasia. As this work was accomplished so more attention was devoted to the fisheries. This became increasingly urgent as the Government was committed to encouraging development of the coastal fisheries with no knowledge of their probable magnitude. The first yield estimation for a single species fishery in one area was made in 1972. Further work followed on localised fisheries and an overall picture of the resource potential was beginning to materialize when, in 1976, the Government decided to declare a 200 mile Exclusive Economic Zone. Preliminary legislation was introduced on 1 October 1977 and the full EEZ Act became operational from 1 April 1978.

Prior to 1976 very little work had been done on the offshore demersal resources and though some studies had begun on the coastal pelagic fisheries which seemed to afford opportunities for industrial development, the main effort had been concentrated on the coastal demersal fisheries which were the basis of the local industry.

The EEZ for which New Zealand has now assumed management responsibilites covers 1.4 million square miles of ocean though only about 40% of this is trawlable, i.e., has depths less than 1 000 m.

From 1959 the Japanese had fished the outer shelf beyond 6 and then 12 miles and the edge of the slope gradually extending to deeper water. From about 1970 the U.S.S.R. had fished the deeper more offshore waters particularly to the east and south. From 1975 the Japanese substantially increased their longline fleet in the area and in 1976 trawl and longline vessels from the Republic of Korea also moved to the New Zealand area. The Japanese squid jig fleet first began fishing in 1972 and throughout the period from 1965 Japanese, Korean and Taiwanese tuna longline vessels had fished in the general vicinity of New Zealand.

Manpower resources for fisheries research are limited. The Research Division deals with all aspects of marine and freshwater fisheries. Currently there are 15 scientists, with supporting technical staff, concerned with fin fisheries (no shellfish of significance are vulnerable to foreign vessels). Twelve are fishery biologists of whom 4 are engaged on the deepwater trawl fisheries, 5 on coastal demersal fisheries and 3 on pelagic fisheries. The remaining 3 are biomathematicians working with the biologists on resource assessments.

There are 2 research vessels, the 20 m IKATERE confined to inshore fisheries of the northeast North Island and the 42 m JAMES COOK working on the balance of the fisheries. The 30 m technology vessel W.J. SCOTT is also available from time to time for coastal studies.

The research group has its own computer and access to central government computers for large volumes of data.

Sources of Information

Local fishermen are legally required only to furnish monthly returns of total landings by species and days at sea. Some provide more detailed data but the statistical system is badly in need of modification.

Data from foreign fishing vessels has varied considerably but from early sighting reports and from information supplied for area 81 (Southwest Pacific) included in the FAO Yearbook of Fishery Statistics, it was possible to derive information on seasonal concentrations of species and to obtain minimal data on total catch by species.

The only detailed data was supplied by Japan. The Fisheries Agency tabulates catch weight by species, by number of tows, by area, by vessel size for all its trawl fleet and these data were made available. So too were more detailed tow records and catches with some breakdown of species by size groups caught by research vessels.

These data, plus some distributional and biological data, particularly age/length relationships, age/size at maturity, depth relationships, etc., obtained by New Zealand staff were used as the basic sources of information for calculations of Total Allowable Catches (TACs).

Estimation of the Size of the Resources and Calculations of TACs

Because the effort in the deep water has only been applied for a few years it was assumed that stocks beyond the immediate shelf were in an almost virgin state. Therefore, extrapolation of total catches and c.p.u.e. might over-estimate the sustainable yield.

Conversely as effort was concentrated in a few areas on a seasonal basis the catches were not necessarily indicative of the potential of the whole area, particularly as independent New Zealand studies suggested that there were several discrete stocks of some species within the zone.

Using data from Japanese research cruises, crude estimates of the total biomass by swept area were made and extrapolated on the basis of known available trawling grounds. With estimates of the mortality coefficients F. & M. from biological data, tentative figures for sustainable yields have been derived and from these a "Safe Biological Yield" of 2/3 of these figures was calculated as a TAC for each sub-area.

As a cross check, data on the productivity of the EEZ has been aligned with what is known of other commercial fisheries in similarly productive waters.

Some of the sub-areas of the EEZ are unavailable to the New Zealand fleet and the total SBYs have, therefore, been allocated as quotas to foreign vessels. In other sub-areas where the outer shelf is, or can be, fished by local vessels the quotas have been reduced by the anticipated catch by the New Zealand fleet.

Inevitably the estimations are crude, particularly as the most detailed data from Japanese vessels does not include some of the areas heavily fished by other countries from which similar detailed information has been unobtainable.

TAC calculations were made on figures available up to and including the 1976 fishing year. In all cases the catches by foreign vessels in 1977 were substantially higher than in 1976 and considerably in excess of the TACs. Figures are now being revised on the basis of the detailed catch records that foreign fishing vessels are now obliged to furnish.

Scientific Advice on Catch, Levels, Quotas and Controls

As indicated, the present TACs are a deliberate underestimate of the anticipated potential yield. However, it is anticipated that by the end of the first fishing year, i.e., 31 March 1979, sufficient additional information will be available from the catch records to contemplate some revisions at least for the trawl fisheries. The increasing catches by bottom longline vessels present a separate problem in that there are few substantive data and little information which can be used to relate c.p.u.e. to potential sustainable yields. This also applies to the squid fishery. The Japanese jig fleet catch has fluctuated from 3.9 tons to 1.5 tons per boat day and it is assumed that the resource can sustain at least the past level of effort. Squid are also taken by trawling and allocations have been made on the basis of past catch records up to 1976. Similarly it has been assumed that provided the tuna longline fleet does not increase, the level of exploitation will be in keeping with the size of the resource.

As far as the trawl fisheries are concerned it does appear that some species are very restricted in their distribution and consequently can be subjected to very heavy fishing pressure over short periods. For example hake off the West Coast of the South Island and silver warehou to the east of Stewart Island occur seasonally in dense concentrations in relatively small areas. There is already evidence that catch rates for these two species have declined substantially over the past two or three years. Ling, too, are believed to be limited in their distribution and spawning grounds. For this season a major spawning area southwest of the South Island was closed to foreign fishing.

In terms of the local New Zealand fleets, prime species upon which they are dependent for economic operation have been relatively heavily exploited by foreign fishing vessels fishing the shelf beyond 12 miles. Though such species, except for snapper, have been taken as by-catch in the course of fishing for more abundant species, the quantities are very significant in terms of what is known of the size of the resources and their sustainable yields. Therefore, a maximum by-catch has been recommended. For example, on the east coast of the South Island though Japan and the U.S.S.R. have been allocated 7 000 and 8 000 tons of trawl fish respectively, each has been restricted to a total catch of 500 tons of warehou and 50 tons of tarakihi.

Such limits, though difficult to administer and certainly not readily acceptable to the countries concerned, are designed to encourage fishing for less preferred species. They are also designed to protect the livelihood of the local fishermen. Also to protect the local industry extensive areas of shelf have been closed to foreign fishing. Although it is doubtful whether the New Zealand vessels will fully exploit all the resources available to them in these areas, the closures have been designed to maintain the economic viability of the local industry.

The New Zealand fishery regulations specify a single cod-end with a minimum mesh of 100 mm for all vessels, local and foreign, except that south of 48° 30' south, a new regulation permits the use of a 60 mm mesh for the taking of southern blue whiting and squid. At the moment there are insufficient by-catch data to evaluate the significance of this change which could be the subject of amending scientific advice.

Because of the limited data available and limited manpower both in the scientific and surveillance/observer areas other control measures have been suggested that help to ensure a flow of data and provides some further level of supervision.

No foreign vessel may fish the zone until it has formally cleared an entry port. Equally no vessel may leave the zone until its logs and catches have been checked. Catchers transhipping to reefer vessels may only do so in specified areas under government surveillance. Therefore, every effort is made to check logs against catches and in addition observers are placed on foreign vessels from time to time. Each vessel must report its noon position daily to the Fisheries Control Centre. These principal regulations provide an opportunity for maintaining control over foreign fishing vessels and their activities and are supplemented by sea-borne and air-borne surveillance data by the Defence Department.

With these controls, plus the information now being collected, it is considered that sufficient data can be accumulated to permit further advice to the Government on quotas and desirable management measures.

Recent Developments

The lack of population and lack of adequate capital within the country makes the development of a wholly owned New Zealand deep water fleet impractical. Therefore, joint venture companies have been encouraged. Allowances for catches by such companies have to be made within the TACs but in some cases, rather than form a new company to immediately exploit the resources, joint venture charters have been agreed, mostly for one year, to test the feasibility of developing sound commercial ventures. One such proposal involves a major survey in which New Zealand scientists will participate and which is designed to incorporate stratified random samples over most of the fishing area within the EEZ. The vessel, a large factory trawler, will provide a useful working platform and the data obtained should substantially increase the knowledge of the resources and their potential.

However, even one such venture which is intended to devote 50% of its time to research, places a great strain upon an already limited scientific staff. If, in addition, foreign nations wish to mount their own research cruises, it will be difficult to ensure adequate New Zealand participation and at the same time an opportunity for local scientists to assess independently the resources and their potential yields. Thus, there is a danger that outside assessments, which have already been made on economic grounds, may be used to persuade the Government to increase quotas beyond those which the New Zealand scientists feel are reasonable at this time.

It is appreciated that, under the LOS, fish surplus to that which can be taken by the coastal state must be made available to foreign nations wishing to fish the zone. Nevertheless it is the responsibility of the state to decide what that surplus is and how it should be allocated.

As already indicated the problem is further compounded in that, as with all mixed species fisheries, some species, usually the less abundant, have the highest value and are of major significance to the economy of the local fleets. To protect these the more abundant species must inevitably be under-exploited, unless more efficient target fishing for such species can be developed (or encouraged under pressure!).

Management for the Future

New Zealand, despite its greater level of sophistication, is in many respects another developing country as far as its fisheries are concerned. On the one hand there is a desire to capitalize upon the resources which are now hers to use or to manage, and on the other a lack of capital to make this immediately possible. Furthermore, there is a serious lack of fisheries and economic data which makes it difficult to evaluate adequately the choices between being landlord, receiving licence fees as rent, merchant, catching, processing and selling the catch; or perhaps a mixture of both, using access to the fishing grounds as a trade off for other commodities of national economic importance in the export field.

One thing the coastal state can do is to manage the total resources to give some optimum yield whether this is in economics or fish production terms, which can result in a stable industry. If, as is believed, the resources are not yet fully exploited New Zealand has the opportunity to develop its fisheries with this goal and avoid the policies of retrenchment which have followed upon most economic zone declarations.

This will in turn require the development of models for the fisheries in which the scientists, at least, can believe. If this can be done and they themselves are satisfied with their own credibility, this may be transferred to the managers as a pattern for development despite external pressures. Possibly a pious hope - certainly a lot of work.

PERSPECTIVE OF FISHERIES MANAGEMENT IN BRAZIL

by

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An analysis of the measures taken in Brazil on fisheries management during the last twelve years indicated a tendency of changes in their objectives and technical-scientific basis.

Fisheries regulations during the 1960s and at the beginning of the present decade were concerned with the protection of the stocks from eventual over-fishing, in spite of the fact that no objective information substantiated such danger. Qualitative measures of control were adopted such as the prohibition of landings of ripe spiny lobsters or demersal fishes less than a minimum size caught by bottom trawlers and others. At that time investigation to determine the effects of the measures adopted were not being carried out; for example, the relationships between the spawning spiny lobsters and recruitment, or studies on selectivity of the meshes of the bottom trawlers were not estimated.

Recent regulations, notably those started since 1974, already reflect concern on the strength of the fisheries or on their economic aspects. Quantitative measures have been adopted to control the fisheries such as limitation of effort. This new measure aims at reducing the pressure on the stocks and also tries to secure a higher profit from the fishing operations.

This evolution from qualitative to quantitative measures was due to the development of the fisheries in part as a result of the introduction of a system of fiscal and financial incentives to the fisheries industry.

By the end of the last decade there was a rapid increase in the number of medium and large boats fishing some resources, mainly pink shrimp, spiny lobster, catfish and sardines, causing a crisis in the production during the first years of this decade. There was a reduction in the profits from the operations of the boats and the total catch of some fisheries. There was in consequence a demand for more and better research to solve the emerging problems and a greater support from the government at a high level. This support resulted in the establishment of programmes for the systematic collection of information which permitted, following the effects of the fisheries on the stocks, a system of coordination of research carried out by the different government institutions and universities and improvement of the control of the fleet operations.

These advances are recent and there is ground for much improvement of fisheries management in Brazil to reach an adequate level of efficiency.

In this initial phase, attention has been concentrated on those fisheries (i) with declining profits; (ii) with catches subject to considerable fluctuations, and (iii) with an accelerating increase of effort.

In the first group are included the fisheries of pink shrimp, spiny lobster, snapper and sea bob shrimp. For these fisheries, the immediate objective of management is to try to stop the declining tendency of the indices of productivity and if possible to reverse that tendency and maintain them at a satisfactory economic level. For this purpose research was carried out to obtain yield curves to know how to manage the fishing effort to attain definite objectives. A second medium-term objective is to determine the effect of quantitative measures in the indices of productivity and in relation to the stocks.

Research into the effects of quantitative measures requires information which is more laborious to collect and higher levels of sophistication to plan their collection and analysis, than does research into qualitative measures. It requires therefore a better trained staff. Of the four fisheries considered, the one for pink shrimp in the south east region already apparently shows positive results because the productivity indices have been relatively stable since 1973 when the control of fishing effort was introduced through a system of special fishing licences for this fishery.

The limitation of the number of boats in the spiny lobster fishery, as a measure to control the effort, did not have the same effect as that obtained in the shrimp fishery. The boats increased continually the number of traps emptied per day and many started to use gill nets, with a fishing efficiency much higher than the traps. Furthermore, the effective control of the gear used in this fishery is practically impossible. Recently closed seasons were introduced (in addition to the control of the number of boats) as another measure to reduce the effort.

The measures to control the snapper and sea bob fisheries are also related to the reduction or stabilization of the fishing effort. They are of very recent implementation and it is not possible yet to evaluate their effects.

The sardine fisheries included in the second group of fisheries have large periodic fluctuations of catches. It is known that the catches depend on the annual recruitment rate which is subject to many variations and is probably not closely influenced by the intensity of the fisheries of previous years. In this case the immediate objective is not to regulate but, if possible, to inform the fishermen in advance about the availability of fish during the next fishing season. This will give the fishermen the opportunity to look for other fishing alternatives during the periods of low availability of sardines. The medium-term objective will be to evaluate possible effects of the fisheries at the recruitment level. The research under way is aimed at two objectives: periodic evaluations of the total biomass of sardines, and the biomass of recruits, by hydro-acoustic surveys initiated in 1974. Unfortunately this has not been done with the required regularity. The results obtained, however, indicate that the present fleet is able to catch about 60% of the total biomass, even in the years of great abundance. Taking into account the negative economic effects, during the years of low availability of sardines, of the increase of the fleet, measures have been taken to maintain it at its present level allowing only the replacement of the old boats. A closed fishing season of 45 days has also been established coinciding with the maximum spawning period of the sardine. This measure was requested by the majority of the fishermen. Efforts are being made to try to evaluate its effects on recruitment.

Regarding the third group of fisheries, those that have registered a progressive increase in the number of boats, the objectives are to improve collection of the data

needed to obtain the yield curve, as well as those that could identify the effects of possible measures to control the stocks. This work is being developed in those fisheries which have a volume of production significant in the whole of the national fisheries.

Besides the problems of fishery management directly related to the commercial fisheries, there is another problem of concern to the fishery administrators in Brazil. It is the subsistence fisheries carried out in bays, estuaries and lagoons which affect the young stages of species of commercial importance, mainly shrimps, croakers and mullets. In view of the intensity of those fisheries in certain areas there is a fear among the commercial fishermen, industries and public opinion that it could destroy the stocks.

The most practical solution for this type of problem is, through projects of technical and financial assistance, to help the fishermen to operate in open areas and on adult stocks However, it is not always possible to achieve this objective, entirely or partially, in view of the magnitude of the human and financial resources required.

Direct actions, such as regulation of the fisheries, have encountered technical difficulties. It has not been possible yet to design models of research of adequate function and operation which would answer some fundamental questions such as: how has the capture of young fish by the subsistence fishery affected the stocks or the yield of the commercial fishery of those stocks? Up to which point will it be socially or economically advantageous to stop the subsistence activities in order to benefit the commercial fisheries? Another factor has been gradually added to the problem, making it even more complex. It is the urban development in the neighbourhood of the subsistence fisheries areas causing their pollution. How can the two factors be evaluated separately?

In the medium and long-term, the solution of these problems may come from a global development which may absorb the subsistence fishermen into other better remunerated activities. Regarding the pollution, the solution is more lengthy and difficult because the processes producing pollutants would first have to be stopped and, at a second stage, the environment would have to be restored. The specialized government agencies, with the growing support of public opinion, are taking the first steps in this direction.

Regarding the management of inland fisheries their stage of development and production is still incipient and for this reason empirical measures for the protection of the stocks persist.

In the Amazon region, for instance, there are minimum sizes of capture for various species. In the flooded basin of Mato Grosso commercial fisheries are not allowed. Fishing during the spawning migrations is also not permitted for some species. During this period it is possible to obtain large catches of these species.

In the main river basins of the country research centres have been or will be established. The main objective of their programmes of work is to collect basic information on the nature and quantity of the existing fishery resources.

In a developing country like Brazil with dimensions of a continent having regions with distinct environments and cultures, with coexisting technologically advanced and primitive fisheries, where fisheries occupy a discrete position in relation to the economic importance of other activites, in which the social problems of fisheries are diluted

among those of other sectors and in which there is a great variety of species, the scientific and technological development of the fishery sector is in an early phase. The precise determination of wide ranging and long-term objectives for fisheries management does not seem realistic considering that simple and immediate problems are still to be solved. The evolution should be gradual based on the experience of each small success or of the errors committed.

The adoption of regulatory measures of the fisheries, besides being scientifically and technically based, must be respected by the fishermen or the industry and they must believe in their efficiency. The seeds for the evolution of fisheries management in Brazil have been planted. The environment is favourable for their budding. The need for proper management of the fisheries is recognized as well as the fact that management requires the support of research. This is recognized not only by government but also by the fishermen, boat owners and industrialists. They are already participating effectively in the process.

The essential seems to be a continuous effort for the improvement of the institutions and systems, in the recruitment of new research workers, in the education of new specialists and in the continuous training of all staff concerned with the fisheries activities.

A BRIEF REVIEW OF THE EVOLUTION OF RESOURCE MANAGEMENT ADVICE IN THE ICNAF AREA 1965-78

by

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Introduction

As a background to the Working Party's review of concepts and models of resource assessment and management in the light of extended fisheries jurisdiction, it is worthwhile to examine the evolution of concepts and methods of resource management in the ICNAF area under international management. The effectiveness of scientific advice can only be judged in the context of constraints imposed by the overall fisheries management regime.

Examination of the reports of the Standing Committee on Research and its Assessment Subcommittee in ICNAF reveals a steady progression. An observed and projected trend towards excessive fishing effort catalyzed the evolution of management measures. There was a steady increase in the variety of regulatory measures, in the number of regulated species and stocks, in the quantity and quality of data made available and in the sophistication of scientific analysis.

It is also evident that the debate on the basis and methods of giving management advice has ranged more widely than is evident from the measures adopted. The need for simple rules to which all parties can subscribe, limiting the possibilities of interpretation or misinterpretation of always limited data have eliminated considerations known to be important to the economics and welfare of the fisheries but which defied simple quantification.

ICNAF Convention

The ICNAF Convention, signed in 1949 and entering into force in 1950, was developed in response to internationally perceived problems of reduced fish abundance especially in New England waters and to potential overfishing.

Article VIII defined the terms of reference and procedures for the development and implementation of conservation measures. Specifically:

> II The Commission may, on the recommendations of one or more Panels, and on the basis of scientific investigations, transmit to the Depositary Government proposals, for joint action by the Contracting Governments, designed to keep the stocks of those species of fish which support international fisheries in the Convention area at a level permitting the maximum sustained catch by the application, with respect to such species of fish, of one or more of the following measures:

(a) establishing open and closed seasons;

(b) closing to fishing such portions of a subarea as the Panel concerned finds to be a spawning area or to be populated by small or immature fish;

(c) establishing size limits for any species;

(d) prescribing the fishing gear and appliances the use of which is prohibited;

(e) prescribing an overall catch limit for any species of fish.

Advice was channelled through a series of panels corresponding to subareas of the Convention area. Commissioners of member-countries were assisted by experts or advisers in Panel meetings.

Under Article VI, the Commission was responsible for obtaining and collating the information necessary for maintaining stocks of fish in the Convention area.

History

It has been estimated, for example ICNAF Redbook 1975, page 56, that the level of fishing effort in the ICNAF area about 1960 approached that corresponding to maximum sustainable yield from the fish stocks and then proceeded to double in the following ten years. The existence of such overfishing was clearly evident to the Standing Committee on Research (STACRES) in 1965. On page 8 of the Redbook for that year, it was noted that, with the possible exception of cod in subarea 2, the fishing intensity on the main cod and haddock stocks was approaching, or even beyond, the level giving maximum sustainable yield. It was noted that the setting of catch quotas appeared to be the most feasible system of regulation possible under the terms of the ICNAF Convention, but there were difficulties in predicting accurately total allowable catches. The importance of economic factors, both when considering the fisheries on several species and in considering changes in fishing effort was recognized. At this time, regulation in the ICNAF area was limited to the control of mesh size intended to maximize yield per recruit in some fisheries.

As concern over the excessive rate of fishing mortality mounted, STACRES recognized the need for better data to assess the stocks. In the 1966 Report, there were recommendations to intensify the scientific investigation of cod in the northern area and of haddock in subareas 4 and 5.

In 1967, STACRES drew the Commission's attention to the fact that with more, large, highly mobile vessels fishing in the ICNAF area, there was likely to be a large temporary increase in fishing intensity on fish stocks subject to large variations in year-class abundance. There were also references to the likely benefits of reducing fishing effort beyond that currently observed.

It was also noted that continuing growth in fishing power was expected and that this greatly increased the urgency for steps to introduce effective control measures in those fisheries. The Committee stressed the continuing importance of mesh regulations for controlling the size of fish entering the fishery. At this point, detailed consideration was

being given to the biological data requirements to support a system of catch quotas for the cod and haddock fisheries.

Debate on regulatory measures

The 1968 Annual Report of STACRES contained considerable discussions about options of controlling fishing effort or catch. The theoretical effectiveness of the two approaches was judged equal. However, the difficulties of measuring and defining fishing effort and the need for precise periodic intercalibration tipped the scales in favour of the system of catch quotas. Progress was being made in the standardization and development of sampling procedures and statistical reporting procedures.

In 1969, STACRES examined catch quotas for subarea 1 cod and subarea 5 haddock. The Committee also predicted a likely decline in the overall level of catches from groundfish stocks in the Convention area, due to the observed high level of fishing mortality. In this year, statistics and sampling recommendations were becoming more specific and urgent, indicating a general acceptance of the need for better sampling and statistical reporting.

By-catch problems recognized

By 1971, the assessments subcommittee was considering seals, cod in all subareas, three haddock stocks, herring, yellowtail flounder, American plaice and scallops. It was at this meeting that the problems of by-catch in a system of catch quotas were officially recognized. A case study was completed for haddock and yellowtail flounder. A 1970 recommendation adopted by the Commission involved the Executive Secretary notifying countries when 80% of the quota had been reached to prohibit direct fishing for these species within ten days of the announcements. The balance of 20% was allowed for unregulated catches and by-catches. This procedure was successful for haddock in 1970 but this was largely due to chance. It was proposed that the closing date be chosen based on real-time estimates of present catches, the quantity likely to be taken before closure and the likely incidental catches after closure.

Global approach

Consideration of the effects of current fisheries on the total groundfish resource appeared in the STACRES report of 1972, together with examination of the effect of total fishing effort in subarea 5 and statistical area 6.

In 1973, extensive discussions on the effect of regulating fishing effort were recorded. This led to a series of working group meetings which served to underline problems of variation in catch rate between vessels and areas and the difficulties of calibration.

The number of stocks under quota regulation increased steadily. In 1974, in an attempt to deal with incidental catch difficulties, a two-tier quota system was adopted in subarea 5 and statistical area 6, whereby individual stocks had quotas and the total catch of all species, including unregulated species, was limited by a second tier which was less than the sum of all the individual quotas.

Revision of MSY objective

In 1975, a proposal for the reduction of fishing effort in ICNAF subareas 2-4 by 40% in terms of days fished was adopted by the Commission. This represented the culmination of the evolution of management advice within ICNAF. This year too saw a special September meeting of the Standing Committee on Research to consider management measures and, at that time, it was recommended that the earlier target of fishing at F_{max}, which was intended to reduce fishing mortality from levels in excess of Fmax, should be reconsidered. The advantages of fishing below F_{max} rate were stressed, these included margin for error in estimation, increased stability of the stock and increased catch rates. These have long been known, but the evolution of the political climate had reached the point when they could be forcefully stressed. The main reference point for management in the ICNAF area, outside 200-mile zones and in the Canadian 200-mile zone at present is the rate of fishing mortality corresponding to $F_{0.1}$, that is, the rate at which the derivative of the yield per recruit curve versus fishing mortality is one-tenth that at zero fishing mortality.

Effects of extended jurisdiction

In 1976, it was clear that coastal states would extend fisheries jurisdiction and the role of ICNAF visibly diminished.

Canada and the United States extended fisheries jurisdiction in 1977 and introduced stringent controls on catch and fishing effort with much more detailed reporting requirements from distant water fleets than had been the case in earlier years.

In 1977, Canada introduced a policy of requesting fishing and sampling plans from countries desiring to fish within the Canadian zone. This has facilitated the coordination of research within the Canadian zone and also raised the standards of scientific data collected for the assessment of fisheries.

Regulatory measures in Canadian and U.S.A. zones have become even more complex with "windows" or limited areas where fishing with certain gears or for certain species is permitted.

The desirability of reducing time lags between assessment and implementation of quotas, together with frequent requests for further advice, has led to final decisions on quotas being made shortly before the start of some fisheries (e.g., special meetings on squid, February 1978, February 1979).

General Conclusions from the ICNAF Experience

ICNAF proved to be an excellent forum for the development and exchange of scientific ideas on resource management during the period when it had management responsibility. It was instrumental in the development of standardization of sampling procedures and in the exchange of other techniques between national scientists.

As a multi-lateral body, ICNAF was handicapped by divergent interests and economics of member states and by the lag times required to bring measures into effect. It must be agreed that, under ICNAF, stocks in the northwest Atlantic declined, but it cannot be

concluded that this decline was due to the inadequacy of the scientific advice and it is extremely doubtful whether more sophisticated analyses, including species interactions and economic variables, would have slowed this decline. In this author's opinion, the effort reduction of 1976 was the most effective measure taken by ICNAF and it is the more rigorous control of the catch and fishing effort now which is promoting the recovery of the stocks within the 200-mile zones of the ICNAF area.

An Alternative

The evolution of fisheries management measures in the ICNAF area has seen a steadily increasing complexity with a corresponding increase in the size of scientific and administrative workloads. The emphasis has been on predicting the effects of various mortality patterns on the stocks and on the corresponding yield. This author would like to propose a rather different point of view derived from that advocated by Garrod, ICNAF Res.Doc. 75/IX/124.

The status of a fish stock is best summarized in a single statistic by its biomass which is closely related to:

(a) catch rates and hence costs of capture;

(b) productivity and hence yield;

(c) size of individual specimens and hence the relationship between product weight and round weight.

Ignoring the effects of fluctuations, maximum benefits can be achieved by maintaining the biomass at an optimal level corresponding to an optimal fishing mortality rate. Fluctuations in growth, natural mortality and recruitment may be absorbed through variations in stock biomass or variation in catch - or a combination of these. Typically, resource managers have tended to recommend constant catch rather than constant stock biomass. The current emphasis on quotas derived by maintaining constant fishing mortality rates absorbs fluctuations partly by varying quotas and partly by varying stock size.

If the relationship between product price and quantity is convex, which it usually is, mean wholesale revenue is higher than the revenue at mean production when production fluctuates. Similarly, if biological productivity of the fish stock is concavely related to stock biomass, which is also usual, average yield for fluctuating stock biomass is less than yield at the mean biomass. Thus, both of these factors result in higher gross revenue to the fishing industry when natural fluctuations are completely absorbed by varying catches with constant, optimal biomass than if any part of the fluctuation is absorbed by varying stock biomass.

Whether these theoretical considerations can be translated into concrete benefits depends on the relationship between economic inputs and varying catches. Flexibility of fleets and processing facilities permitting switching between species and stocks is particularly relevant.

Although the considerations raised here are directly relevant to the basis of management advice, research in this area has been neglected. Improved methods of determining

resource management advice should recognize both uncertainties in parameter estimates and the highly variable nature of growth and recruitment to fish stocks.

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ASPECTS OF FISHERIES MANAGEMENT IN THE NORTH ATLANTIC

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In the mid-1960s when it became obvious that qualitative controls of catch could not restrain the effects of over-exploitation in the North Atlantic, both NEAFC and ICNAF went into detailed discussions between managers and scientists on the choice between catch and effort regulation. The choice was resolved in favour of catch control primarily because, apart from an appalling lack of fundamental effort data in the NEAFC area, catch has the advantage of being a more negotiable and, hopefully, an enforceable quantity. It was also recognized that by itself an effort regulation would not provide the fine control of a mixed fishery necessary to secure many of the benefits of management, and countries resisted the idea of a dual approach regulating both catch and effort because they were unwilling to concede control of both inputs and outputs to an international authority.

Catch quotas were introduced in the early 1970s in ICNAF. In NEAFC they were delayed by political forces but scientists greeted the emerging regime with enthusiasm. In earlier years assessment advice had been couched in the relative terms of the proportional benefit of one or another regulation, usually a change in mesh size, i.e., advising that a certain mesh size will give long-term catches x% greater than the currently used mesh size, without specifying the absolute magnitude of the catch in either case.. The advent of a quota system necessitated a scientific reorientation to provide stock assessments and estimates of potential catches in absolute tonnage terms, but whilst the theoretical adjustments were rapidly achieved (through the general application of Virtual Population Analyses - VPA - or Cohort Analysis) it rapidly became evident that servicing such regulations introduced new logistic demands on scientific resources by way of supporting resource surveys and the very need for an annual review procedure. This became coupled with a domino effect within each resource array: introduction of quota on any primary species immediately caused a transfer of fishing to a secondary species and it rapidly became clear that every potentially commercial species would have to be subject to its own regulation. This raised new theoretical problems of constructing plausible regulations to overcome incompatibility between the species requiring different management measures (second tier catch regulations covering a group of species) but, more important, it caused a rapid expansion in the need for advice on species for which scientific background and data were virtually non-existent. The regulations pulled scientists into the uncertain territory of precautionary quotas: advice was being called for beyond the scientific capability.

The early enthusiasm that a new era had dawned was rapidly tempered by experience in four areas. Lack of progress to cover technical difficulties revealed by the new requirements, the scientific logistic difficulties of servicing the regime, real or suspected

manipulation of historic performance data (e.g., revisions of series of annual catch statistics) to secure national negotiating advantage which undermined scientific faith in basic information, and expedient solutions in the final decision leading almost invariably toward the highest catch option.

The last two essentially political difficulties were well recognized by countries with industries tied to local resources alone and hence deeply committed to effective conservation in their area because of the absence of alternatives. They contributed in some measure to the fishery issues within UNCLOS.

At the scientific level the expansion in assessment loadings rapidly absorbed almost all the available expertise, putting scientists in a 'chicken and egg' situation where they were fully aware of the technical deficiencies of the science but unable to deploy R & D effort to upgrade it.

Given adequate data it is now possible to develop extremely elegant post-mortems on the recent exploitation of a resource. There remain grave difficulties in specifying the current level of exploitation, and in projecting this forward to form a management strategy at either the tactical or strategic level. These technical difficulties are applicable to every resource assessment; they are

(i) the absence of a method to determine uniquely the current mortality (fishing or natural),

(ii) the absence of an independent method to estimate exploitation patterns,

(iii) the lack of a convincing solution to stock and recruitment problems.

The last one is a particularly serious concern in long-term strategic plans to achieve any objectives of management, including those which take account of intra- and inter-specific biological interactions leading ultimately to broad concerns about the multi-species fisheries and, extending the trophic web involved in management, the ecosystem as a whole.

Stock and recruitment and the larger class of multispecies models are proving intractable problems. Indeed they may represent the same problem in so far as each species may have a unique stock and recruitment relationship which must be solved before the ecosystem problem as a whole can be addressed. Certainly the stochastic element in these processes is high enough to raise the question whether the problem is amenable to scientific methodology at all and, more immediately, whether current mathematical tools evolved in relation to a conservative system may be appropriate to an ecosystem where, apart from the boundary constraints, energy is siphoned off and dissipated in a multitude of directions on, so far as we know at present, a largely opportunistic basis depending on the configuration of the ecosystem at that particular time.

Difficult as they are, some of these problems are essentially long term and might never require a management solution if the decision system is constructed to respond to some degree of change from a given state defined by a shorter-term variance of the components. Their existence should not detract from the achievements that have been made.

There is now within each locality of the North Atlantic, and under differing authorities, a comprehensive organization for collecting and assessing data necessary for tactical management for a major part of the catch of all significant commercial resources. Further, the awareness of the technical difficulties has led to wider development of internationally coordinated resource surveys (eggs and larvae, pre-recruits, groundfish, acoustic) to provide independent estimates of parameters required to confirm current exploitation and future recruitment.

Resource assessments are actually done in three ways, by analytical, or generalized production models or by informed judgement. The models are based on the theoretical structures of 1950-60, with progress since then concentrated on expansion and embellishment of existing concepts coupled with more sophisticated and comprehensive systems for acquisition of data and with some theoretical advance in dealing with multispecies problems.

It is of some interest to see how this general scientific framework, and particularly how the available data collection systems have influenced (a) preferences for generalized production or analytical models, and (b) the management advice that has arisen from each approach. Some countries have no infrastructure for the collection of biological data from commercial fishing activity; development of their scientific approach has been largely dependent on research vessel surveys. At the other extreme are countries having this infrastructure which have developed techniques heavily dependent on commercial fishery data and a reluctance to use research survey data in the assessment context for statistical reasons. In general one can see that the survey approach has provided a wide perspective on the effect of exploitation over a range of coincident resources with a predilection towards the 'wholistic' ecosystem approach. The other approach has focussed on single species and a somewhat narrower view of a total resource array in relation to its dependent industry and other interests.

This divergence of emphasis is reflected in the overall approach to management. A wide perspective of all the resources relevant to an industry, coupled with an awareness of scientific limitations yet the need to exert some beneficial management, leads toward a 'coarse' management regime establishing regulations with a wide margin of error which cannot fail to improve stocks. The single species approach necessarily implies a degree of 'fine tuning' in order to secure benefits to and from each one. These attitudes are in turn reflected in the management structure required to achieve them, the 'fine tuned' approach implying a much higher degree of managerial activity to secure the potential benefit.

As a consequence of all these forces we now see some countries, with sole authority over local resources and all participants, moving toward an interventionist regime and carefully controlling both catch and effort. Others with similar authority have regulated catch and the effort of non-nationals, but, desiring to accommodate a wide range of view on utilization, have found difficulty in developing a policy toward national effort. Others closer to the single species line of scientific evolution control catch but have so far made no attempt to control effort, and still others which, for political reasons, remain in a regime of international control similar to the regional fishery commissions, are still finding extreme difficulty in regulating either catch or effort.

Until recently these systems had one thing in common; they were orientated toward the management of resources; they have not been designed for the management of fisheries. Single species management in the absence of a technique for species aggregation can never approximate to fisheries management because virtually every individual fishery is dependent either on one species in several areas/seasons or several species in one area; biologically and technically it will be based on a mixture of species. Further, neither single species nor multispecies regulation of raw material can address the problem of fishery management in toto until it has addressed the costs of extraction.

The necessity for the broader 'fishery' view is widely accepted but in recent years the underlying attitudes have stimulated arguments about the appropriate objectives of management and led toward a controversy which has been accentuated by the failure of the earlier scientific concepts to evolve to embrace the alternatives. It is almost as if a dichotomy has arisen which should have been avoided. An example is the range of views concerning the MSY as an objective and its supposed importance to resource managers. In my view its value has been overstated, mainly by its detractors. In fact it is simply a point of reference in a useful conceptual framework: the framework is fundamental, the MSY is not. Identification of MSY, or the mortality that goes with it, immediately characterizes the direction of change that might be desirable: it is a tool to orientate negotiation rather than an end in itself. Equally there are valid objections to economic objectives. Fishery management requires an amalgam of both as appropriate to a particular set of circumstances.

It is important also to recognize that the managers' objectives may be different. All the technical advisers' physical, economic and sociological goals presuppose administrative and political faith in planning. They conceive of long-term strategic goals whilst the managers are actually concerned with tactical aspects for the very good reason that the decision environment is fluid. What appears to be right today could be wrong tomorrow. Given the complexity of a fishing industry and its interactions, one might argue that the purists' long-term strategies could only be relevant in the horrific circumstances of a totally planned society; their value is debatable. Industries are like the central nervous system: they respond to change and then accommodate. The managers' role is to decide an appropriate direction of change and judge what degree of change can be tolerated in relation to the biological, economic and social constraints. In fact, when is it necessary to do anything? This leads me to the view that there is no 'correct' objective, only a series of options which may be more or less appropriate at a particular time. One can perhaps conceive of a hierarchy of options depending on the state of a resource and its dependent industry and the technical basis for advice (internal options) coupled with explicit trade-off against external considerations - international obligations, alternative use of the environment, ethical considerations, etc. Explicit recognition of the external factors seems to be important because too often in the North Atlantic the central problem, e.g., local economics, has been displaced into a biological issue because of the terms of reference of advisory structures. At the same time increasing knowledge and public awareness has focussed attention on a breadth of issues that may be relevant without providing a perspective on their relative importance, or whether they can be attained.

So what are the strengths and weaknesses of resource assessments and management in the North Atlantic. At the political level its great strength is the recognition of the need for management coupled with the range of management procedures now being attempted

with varying degrees of Government intervention, varying dependence on international collaboration, and varying attitudes to the necessary precision of management from which each country can learn. Its great weakness is the fragmentation of international scientific cooperation which will not allow the comparisons to be properly made and in some areas a breakdown in the dialogue between managers and scientists leading toward decisions heavily influenced by expediency. There is also, in my view, a tendency to attempt too much too rapidly to redress past errors of omission.

At the technical level there is an awareness of the need to integrate the economic consequences. The theory and methodology are probably adequate but data are not available and few attempts are being made to collect them. On the biological side there remain technical deficiencies for both tactical and strategic management purposes. The theory is lacking but the data are abundant - if they are the right data. The main strength of the technical base lies in the rapid organization of data necessary to advise and maintain tactical management procedures. Its defects lie in the diversion of scientific effort from fundamental research to overcome recognized technical difficulties, and associated with it the tendency to incorporate into advice aspects which as yet do not have a proper scientific foundation, e.g., ecosystem management.

REPORT ON THE STUDIES OF MULTISPECIES SYSTEMS IN FISHERIES

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Introduction

Classical studies of fisheries dynamics deal mostly with single populations treated as if they existed independently. Fishery biologists have come to recognize, however, that in many situations the fish stock cannot be so treated. To a steadily increasing extent, modern fisheries are concerned with harvesting a wide range of species living in the same body of water. The exploited populations of interest are interdependent with others (which may be either exploited or unexploited) through competition or predator-prey relation. Any effect of exploitation on one stock may produce a reaction in another, resulting in readjustments in both populations, and invalidating the expected response to exploitation based on single-species dynamics.

The management problems arising from multispecies fisheries have been recognized. Since yields of different species are maximized at different effort levels and it is impossible to adjust the fishing effort to each level so as to maximize the sustainable yield of all, some populations will be overfished and some underfished. In fact, it is likely that, in multispecies fisheries, species of lower productivity are progressively eliminated or pushed close to extinction as the fisheries harvest the more productive species to the level of their supposed maximum yield, as pointed out by Larkin (1977). The results of such changes on the stability of the fish community are virtually unknown at present, although the effects of species succession on the exploitation such as those in the Great Lakes (Smith, 1968) are expected.

The extension of coastal state jurisdiction up to 200 miles added a further dimension into this complex problem. This action would bring virtually all fish stocks within coastal state jurisdiction. The first paragraph of Article 61 of the Informal Composite Negotiating Text assigns the responsibility to the coastal states for determining the allowable catch of living resources in their exclusive economic zones. The problems then immediately arise of the principles that should be used in determining these allowable catches. The uncertainty of the general applicability of the single-species models, the interactions between species and also the influence of environmental fluctuations are making it difficult, even for the developed coastal states, to estimate the sustainable yields from the multistock, multispecies and multigear fisheries. Needless to say the developing countries with less capacity in the art of fisheries science have greater difficulties.

A study therefore of the dynamics of the multispecies system becomes important to the developing countries, while at the same time being of considerable value to the fisheries science in general. An André Mayer Fellowship was granted to the author by FAO with the following objective:

> "to study and develop models which would provide the basis for a good understanding of events in a multispecies community that occur under exploitation and for deeper and more fundamental study of the subject."

This objective should be met by:

(a) identifying the required statistics and other data necessary to undertake such studies;

(b) identifying information on feeding habits and other behaviour factors required to study the species within the system; and

(c) developing suitable theoretical models which will take account of the direct effects of fishing on each species, and the interaction between species.

This report presents a critical review of the existing multispecies models, problems and proposed programme of field study that should be carried out in accordance with the terms of assignment.

Multispecies Models

Despite the general concern, effort towards solution of what has been called the multispecies problem has been diffuse and uncoordinated. While considerable work has been done on the single-species system, very little work of value has been undertaken on the effects of fishing on multispecies systems. In fact, there is little evidence of a generally recognized concept as indicated by recent meetings on the multispecies fisheries problems (Hobson and Lenarz, 1977; FAO, 1978). It may be because there are so many variations of the problems. A large amount of recent literature on modelling abundantly demonstrates that a wide variety of unexpected consequences can flow from what seems to be simple management strategies for these fisheries.

The first attempt was made on the multistock problem by Ricker (1958) and later by Paulik *et al*. (1967) for salmon management where escapements were known and could be regulated. The application to other species elsewhere is therefore limited. On the other hand, Rothschild (1967) and Pella (1969) suggested stochastic models for multispecies fisheries where there is competition for fishing gear rather than among the species concerned - the technological interaction as called by Pope (1977, MS).

For the interspecific interaction which is the crux of this problem, Larkin (1956; 1963; 1966) pioneered the mathematical examination of the interactive relationships for two species in the form of Lotkva-Volterra equations. Silliman (1969; 1975) employed these equations to investigate the interactions among species and the resulting yields from analogue computer simulations. He suggested that the competition theory may account for a substantial proportion of the variation in the Pacific anchovy biomass. Pope and Harris (1975) also explained the effect of interspecific competition between the South

African pilchard and anchovy stock complex based on a similar formulation. Many other attempts were made along these lines although few were applied to the actual fishery situations. For example, Lord (1971) formulated a general multiple species production model with interspecific interaction terms and performed some mathematical analysis of the logistic form. However, there has been no attempt to apply the model to an actual fishery. Nevertheless, one important feature of such interacting populations emerged from these studies, as shown by Pope (1973, 1976), Silliman (1975) and Horwood (1976), is that where two species are interacting the total yield from an interactive system would be lower than the sum of the individual species MSYs. The maximum attainable yield however lies within a parabolic dome whose sides are defined by the loci of species mortality rates generated by the fisheries. For highly interactive fisheries, the yield region is rather narrow and the total yield is not much greater than that which would be achieved by the fishery for either species separately.

The third approach for the multispecies problem was taken by expanding the basic interactive model into the "whole system" or trophic-dynamic models. By identifying the appropriate trophic assemblages (e.g., indirect indices of the degree of interaction and organization within fish assemblages, indices of feeding success, growth and feeding relationships, metabolism, etc.), food intake, and biomass, the models of the energetics of the natural populations were constructed to predict the reactions of the system to changes in the structure of the populations and their environment. Among these groups are those of Riffenburgh (1961, 1969), Garfinkel (1967), Patten (1969), Parrish and Saila (1970), Paloheimo and Dickie (1970), Saila and Parrish (1972), Regier and Henderson (1973), Timin (1973), Stewart and Levin (1973), Hackney and Minns (1974), Parrish (1975), Jones (1976), Andersen and Ursin (1977), and more to come. It is interesting to note that, while emphasis on the ecological approach is made and generally accepted, nearly all of these models were still in the experimental stages with no applicability for the actual management or conservation of the species under study. It is apparent that attempts have been made to deal with the problems of energy flow and species diversity in natural communities. However, the problem of major concern to marine ecologists, as well as to marine fishery biologists, is how to quantify and analyse the complex patterns of passage of energy among fishes and other trophic levels in the marine environment. Testing such theories in natural setting is also extremely difficult and suffers from lack of control on other exogeneous factors. It might well be summarized at this stage in the words of Patten in 1969 that:

"A definitive rationale for ecological modelling has not been invented yet. There is little agreement about what constitutes a valid model since all modelling is abstraction and biologists are inclined to be concerned with realities. Models having predictive and analytical capabilities with real world relevance are an ultimate goal, but until technical problems relating to the abstraction process are resolved the greatest value of dynamic ecological modelling is likely to remain what it is at the present time - heuristic."

Nevertheless, in the author's point of view, these attempts are encouraging evidence that the multispecies problem is increasingly well-recognized and is already receiving much well-deserved attention at present.

As a series of multispecies models were constructed and presented in the past decade, certain questions that would arise are: what do we expect from these models? what would

be the criteria for good models, academic as well as practical ones, for management purposes? While the former may try to explain ecosystem dynamics from sunrise to sunset or even throughout the year, the fishery dynamics aspect would seem to concentrate on the following questions to be answered from the multispecies fisheries model:

(i) Can an interdependent or interactive model be made to fit reality reasonably well?

(ii) If the fit is adequate, what are the extrapolations for abundance and catches of species concerned?

(iii) What would be the mix of fishing efforts in these interactive fisheries that would, without upsetting the ecological balance, optimize

  (a) the target species catch, and

  (b) the combined species catch?

(iv) For the mixes of fishing effort, what are the projected catches of species concerned?

(v) Can we affect population abundance generally by the control of fishing intensities?

(vi) If so, how delicate must this control be? For example, can we optimize catch while maintaining ecological balance or are we likely to upset the ecological balance with the slightest change in fishing intensity?

The closest model that can answer some of these questions is that of Andersen and Ursin (1977) which was used for multispecies fish stock assessment in the North Sea (Ursin, 1977). Regrettably, the great amounts of predetermined parameters required, as well as many that have to be obtained from simulations for the best fit to the previous catches, made it less applicable to other fisheries which have short history of fisheries and fishery research.

It is apparent that the success of multispecies models depends critically upon the quality of the data set on which they are based. The available data therefore dictate the choice and also the outcome of the models to be employed for a particular purpose. Lack of appropriate data at a number of levels of specificity and of temporal and spatial scope, for both strategic and tactical purposes, was pointed out as the main hinderance for the progress in this field at both expert meetings on the multispecies fisheries problems (Hobson and Lenarz, 1977; FAO, 1978).

With this fact in mind, the author views the development of the multispecies models as five levels of progression outlined in Table 1. At the most basic level, Level 1, only some exploratory work has been done, with little fishing, but crude estimates of abundance and nature of the existing communities in the area, as well as of basic production, could be made to guide the fishery development schemes. When the fisheries have been in existence for some time and catch and effort data become available from properly designed fishery statistic systems, the fishery scientists could progress into the second level and estimate overall fish production and the optimum fishing effort required for management. Most of the fisheries of the world are still at this stage, with a greater or lesser degree of satisfaction. The use of surplus production models has been generally adopted for multispecies fisheries, with some adaptations to the catch/effort analysis to suit the

particular characteristics of the fisheries under study (see Chikuni, 1976; Clark and Brown, 1975; Hongskul, 1975; Brown et al., 1976; Pinhorn, 1976; Halliday and Doubleday, 1976; Boonyubol and Hongskul, 1978). Of course, the validity of the use of this model without a specific study of the interactions among the species presented in the area has been criticized. Nevertheless, as pointed out by Gulland (1976), the immediate day-to-day management needs are to determine what is happening, i.e., what are the net effects of changes in the amount of fishing (including the indirect effects through interactions between species), rather than why and how these effects take place. The main problem lies on the refinement of catch per unit of effort analysis, particularly when the catchability coefficients change with the abundance of stocks as suggested by Fox (1974), Garrod (1976) and Ulltang (1976; 1978).

Table 1

The development of multispecies models and their expectations at each progressive level

Level	Progression	Data required	Expectation
1	Exploratory	Standing crops Primary production	Virgin biomass Potential yield Fish communities
2	Production models	Catch/effort Fishing strategies	Overall MSY Optimum effort
3	Biomass models	Mortality rates Catchability coefficient Biological parameters	Species TACs Mesh regulations Effort regulations
4	Interactive models	Foodweb analysis Plankton analysis Life-history	Management options Effort control
5	Ecological models	All-level productivity Ecological coefficients Energy transfer	Overall production Conservation

Among fisheries in temperate waters where ageing of fish is possible, the use of Virtual Population Analysis (VPA) opens the door for the investigations on variations of fishing mortality rates with age, as well as on the catchability coefficients mentioned above. These additional types of information lead to the third level of multispecies models, where the changes in biomass of various species are investigated and related to the catches. The interspecific interactions might be revealed through the changes in the biomasses of interactive populations. Some properties in the ecosystem such as replacement and species succession can be studied, as shown by Smith (1968) and Daan (1978). Moreover, even the effects of environmental fluctuations in fish production can be examined (Doubleday, 1976; Lett and Kohler, 1976). It is rather unfortunate for the

tropical fisheries that this magic door remains closed due to the lack of suitable ageing techniques.

While practising the applications of multispecies models at Level 2 or 3, another group of biologists may enjoy the entrance to Level 4 by examining the interspecific relationships in the fish community. Analysis of plankton data as well as early life histories are indispensable to the understanding of the role of interspecific interactions, which occur more strongly during the larval stages than at other periods of life. The classifications of major herbivorous and carnivorous plankton, fish larvae and juveniles according to their feeding habits will certainly enlighten the study on energetics in this ecosystem in the long run. For the adult fish, foodweb analysis as shown by Maurer (1975; 1976) and recently by Grosslein et al. (1978) served as examples for this approach. In the short-run, these studies are also of value in identifying and classifying the interrelationships among the major economically important species groups in the fisheries. The economical consideration may also serve as one of the criteria in selecting groups for study of interactions at this level.

Undoubtedly, it will take some considerable time before one could gather enough information to investigate the dynamics of ecosystems. The details of Level 5 are beyond the scope of the present study. The only suggestion for the fishery biologists, not for management, is to keep a close watch on the advances in the field of ecosystem analysis so that any relevant information could be collected at the proper time. Observations and experiments relevant to this aspect should also be encouraged for better understanding of the system under which the fisheries in future will be operated on a long-term basis.

Application to Tropical Fishery Management

While the fisheries in temperate zones consist of few exploited populations with a long history of fisheries research which provide enough information to experiment with multispecies models, tropical fisheries suffer from lack of data and numerous populations. The task of fisheries management in the latter case becomes much more complex due to the varied social, economic and political objectives that society as a whole can pursue. Unfortunately, most of the developing coastal states with the new responsibility for the conservation and management of fishery resources lie in the tropical region. The need for practical management schemes for these multispecies fisheries is therefore greater than ever.

One must always bear in mind that management of tropical fisheries cannot wait for the better data and more research required in a refined model, since the fisheries are developing fast enough to over-exploit the resources within a short period of time. Experiences from the trawl fishery in the Gulf of Thailand indicated that the MSY was attained within only five years after the beginning of the expansion of trawl fishing in the region. Similar phenomenon was observed in the scad (Decapterus spp.) fishery of Thailand. The fishery biologists are therefore assigned a difficult role in this dynamic situation, that is, to detect changes in the state of stocks and diagnose them, with an awareness of the time lags that are inevitable between the provision of advice based on scientific analysis and the enforcement of regulations as they are finally adopted by the fishery administration.

The difficulties of rational management of these fisheries have been recognized. On the other hand, the increased expectations of the coastal states to develop or expand the fisheries in their newly acquired exclusive economic zones and to invest more heavily in fishing effort will eventually lead to a mutually destructive race for the common resources, both biologically and economically. The sophisticated multispecies fisheries models will not serve the needs of fisheries authorities concerned. An alternative approach may be to develop a down-to-earth model for diagnoses of the state of the exploited stocks and advice in respect of management measures such as effort control (direct or indirect) and control of the age or size at which fish are first exploited (e.g., mesh size regulation in trawl fisheries).

For the study of multispecies fisheries at the initial stage, the production model has the great advantage of simplicity as shown by Pope (1975; 1976) and Brown et al. (1976). The experiments by Silliman (1968) and Lett and Kohler (1976) as well as that of Doubleday (1976) also confirm the applicability of this type of model to fishery problems with multispecies interactions and environmental perturbations.

Pope (1975; 1976) has extended this model into the mixed-species fisheries problem as already mentioned earlier. He shows that, if a multispecies fishery conformed to this model and if the development of fishing effort on the system occurred with a constant ratio between the efforts on different species, the form of the yield curve for total catch would be a parabolic function of total effort. Theoretical consideration of two interacting fisheries however indicates that the overall MSY will be associated with a particular species composition and its achievement will depend on the composition of the actual catches being matched to the 'optimal' species composition. In other words, the general production model does not necessarily indicate the MSY of a complex. The true MSY is only likely to be achieved by a very mixed, i.e.,indiscriminate, fishery and resulting in a progressive change in species composition in the multispecies system.

While Pope's interactive production model deals directly with the multispecies fisheries problem and requires less parameters than would an analytical multispecies model (e.g., that of Andersen and Ursin), its use is limited in practice since it still requires a considerable number of parameters. For the n-stock system, the parameters would be equal to $(n+1)^2-1$, which made it rather difficult to apply to the tropical fish communities. Pope (1977) however suggested an approximation for managing multispecies fisheries where the parameter values are unknown by trying to achieve maximum yield by maintaining each species at about half the level of its unexploited biomass. In practice this is equivalent to the strategy derived at Level 1 of the multispecies models described earlier.

Pope (1977) also proposed an alternative method to deal with a complex fishery by employing the principle component analysis. He shows that tropical multispecies fish stocks, at least in the Gulf of Thailand, tend to support a fishing effort which does not discriminate very much as regards which species is caught. Therefore there is the tendency for the fishing mortality rates to increase in a fairly constant proportion on each species. The conditions for an overall yield curve to be applicable are therefore broadly satisfied and the MSY given by an overall Schaefer curve can be used. A principle component analysis of demersal catch rates along the Indian Ocean coast of Thailand indicated similar results.

It is important to note that, without reliable estimates of catchability coefficients for the various stocks under exploitation or the estimates of fishing mortality rates of each stock, the application of multispecies fishery models for management purposes is likely to be at Level 2 for the time being. In the meantime, however, biological investigations on feeding habits throughout the life history of major species, surveys on the abundance of plankton, eggs and larvae and so on should be encouraged so that a better understanding on the inter-relationship among the exploited fish populations will be prepared for higher-level models to be applied in the future.

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MANAGING FISHERIES

SOME DESIGN CONSIDERATIONS

by

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Attitudes, according to Webster, refer to one's "mental position with regard to a fact or state." 1/ For those concerned or responsible for any complex situation or field of endeavour, the aggregate influence of attitudes certainly must be accounted for. The management of the world's fishery resources offers a particularly striking setting in which prevalent attitudes have only been partially perceived, even though such attitudes have evidently driven both research and practical management in ways that many are now questioning. A search for better practices has begun, but this quest proceeds without benefit of a fundamental reappraisal of the underlying "mental positions" that help to explain the current state of knowledge and action. Indeed, palliative measures contemplated or taken in the absence of some clarification of the attitudinal bases upon which past practices have evolved may only worsen, not improve, the current and future states of affairs.

One important function of policy analysis is to question and then redefine existing situations and practices so that better ones might result. 2/ For instance, situations of pure conflict in which one side's gains appear to be made only at the expense of an opponent often have a potential for being recast so that all players are left at least somewhat better off as a result of undertaking a previously unrecognized option. 3/ Such redefinitions and identifications of areas of common interest have the potential of creating policy options unlike any that have inhibited past performance; they also often lead to the creation of institutional and organizational supports that enable the newer options to flourish. In short, policy analysis - according to this conception of it - is a call to change existing systems. 4/ A necessary first analytic step is redefinition, which proceeds by diagnosing a present situation and then reorienting or changing common perspectives, attitudes, and perceptions.

1/ Webster's Seventh New Collegiate Dictionary (Springfield, Mass.: G. & C. Merriam, 1967), p.57.

2/ Edward S. Quade, Analysis for Public Decisions (New York: Elsevier, 1975). "Policy analysis is valuable because it can help a decision-maker by providing information through research and analysis, by isolating and clarifying issues, by revealing inconsistencies in aims and efforts, by generating new alternatives, and by suggesting ways to translate ideas into feasible and realizable policies." Pg. 11.

3/ James S. Coleman, The Mathematics of Collective Action (Chicago: Aldine, 1973), pp.52-60.

4/ A constant source of agitation for such change in the general field of inquiry at issue here is Myres S. McDougal and William T. Burke, The Public Order of the Oceans (New Haven: Yale University Press, 1962)

The Present Situation

The kinds, amounts, distribution, and habits of the world's stock of fin fish are largely unknown. Even when numbers are available, they are subject to a variety of interpretations as to what they mean. 5/ In the 1970s, "about 58 percent of all landings of fin fish by weight and 44 percent by value ... were taken within the three miles of the United States." 6/ Similarly, less than 5 percent of the total catch came from the Southern Hemisphere in this particular period, despite the fact that more than 80 percent of the ocean area of the world is found there. 7/ Even allowing for Nature's vagaries, including the fact that the Northern Hemisphere is disproportionately endowed with production shelf areas, one must believe that the Southern Hemisphere may offer great potential in the twenty-first century in terms of the development, exploitation, and management of marine resources. Potentials exist elsewhere, too.

For those few areas where basic statistics have been collected, such as the North Sea fishery, the identification, assembly, and maintenance of data have proven to be formidable, time-consuming, and expensive tasks. 8/

> "It is a matter of history that, for the best-known and most studied fishery in the world, it has taken approximately fifty years to introduce its first international regulation, only to find that there are still many problems to solve. What is important, however, is that it is now possible to foresee some of the dangers as well as to predict with some certainty the prospective benefits. This is only because there are now available long series of statistics, steadily improving in precision for conservation purposes, albeit still not entirely adequate."

For the most studied fishery in the world more than seventy-years and unknown thousands of man-hours have been expended in the collection of basic information whose utility for policy and management purposes is still subject to dispute.

Progress in primary data collection has been remarkably slow and there are few reasons to believe that this will change in the foreseeable future. Not only are there

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5/ Martin D. Burkenroad, "Theory and Practice of Marine Fishery Management", Journal du Conseil Permanent International pour l'Exploration de la Mer, Vol.18 (1953), p.300. This source is somewhat dated, although one suspects that the general conclusion is not without substance some 25 years later.

6/ Gerard J. Mangone, Marine Policy for America (Lexington, Mass.: D.C. Heath, 1977), p.152.

7/ United Nations Food and Agriculture Organization, Yearbook of Fishery Statistics (Rome: FAO, 1970-72 series); and U.S. Department of Commerce, National Marine Fisheries Service, Fisheries of the United States (Washington: Government Printing Office, 1971-1975 series).

8/ Cyril E. Lucas, "Regulation of North Sea Fisheries under the Convention of 1946," (1955), pp.167, 177, as cited in McDougal and Burke, op. cit., pp.462-463. (Emphasis added.)

few identifiable resources, including numerous capable people, being expended for these purposes, 9/ but the very complexity of the object of the study has limited progress in this area. 10/ Indeed, fishery management appears to be confronted with a near classic, circular problem: We have very little good analysis because there is so little usable theory; we have little usable theory because there is so little solid information and data; but there are few decent data because there have been so few good analyses to generate theoretical insights that would tell which data to collect. It is a problem made all the more difficult by the related facts that investment capital, credit, and insurance instrumentalities are all apparently in very scarce supply and hence limit the exploration and development of new fisheries, with the result that solid empiricial information about the true potential of the world's fish resources is slow to accumulate.

Theoretical development appears to be at a fairly rudimentary level, especially as compared with closely related fields of natural resource economics, 11/ pollution assays, 12/ or the modelling of estuary systems 13/ - all topics of high potential relevance to fisheries management as traditionally considered. One implication of this uneven theoretical development is that by carefully selecting and drawing on work from these and other related fields, progress might be stimulated and speeded.

One general result of the current state of data and theory in fisheries management is the increasing demand being placed on the few scientists in the field to provide definitive, if not authoritative, answers to contentious policy questions. When, as must necessarily be the case, a policy-maker's query is met with equivocal and guarded replies derived from tentative and uncertain models of systems only vaguely understood, the prevalent tendency to dismiss or overlook scientifically-based advice becomes all the more understandable.

9/ One is impressed, on reading any representative collection of fishery studies, by the small scale and narrowly biologic character of the questions and researches that are being undertaken, as compared with the large-scale and more-than-biologic character of the management and policy problems that fisheries represent. F.R. Harden-Jones, ed., Sea Fisheries Research (London: Elek Science 1974), is exemplary in this regard.

10/ C.W. Clark, Mathematical Bioeconomics (New York: Wiley-Interscience, 1976), is a quite nice departure from the usual in terms of its explicit consideration of several of the more relevant complexities of this system.

11/ Stephen L. McDonald, Petroleum Conservation in the United States: An Economic Analysis (Baltimore: Johns Hopkins University Press, 1971); and Robert J. Kalter and William A. Vogely, eds., Energy Supply and Government Policy (Ithaca, New York: Cornell University Press, 1976), are illustrative.

12/ Richard Stone, "The Evaluation of Pollution: Balancing Gains and Losses," Minerva, Vol.10, No.3 (1972), pp.412-425

13/ Jan J. Leendertse et al., A Three-Dimensional Model for Estuaries and Coastal Seas (Santa Monica, Calif.: The Rand Corporation, R-1417, December 1973 [including others in this series]); and B.F. Goeller et al., Protecting An Estuary From Floods (Santa Monica, Calif.: The Rand Corporation, R-2121 through 6 December 1977), in which fisheries are treated in a relatively wholistic setting (Vol. 3).

Furthermore, such a response even begins to look rational when the scientists argue among themselves about what even the most fundamental concepts and measurements are and mean. For instance, the concept of maximum sustainable yield (MSY) has received much research attention, primarily because it spotlights conservation goals shared by many in this group; however, even within this group solid consensus still does not appear to have been attained and the issue is far from resolution. 14/ Outside of this group, particularly with respect to economists and politicians, the concept and the goal it represents are even less generally understood and embraced, respectively. 15/ Indeed, to the extent that scientific analyses do not treat such issues as the economics of the fishing industry (including profitability and technological innovation), the quality of the life fishermen lead, the optimal social end use of fish resources, and the provision of fish to consumers in steady, dependable supplies at reasonable cost, one must judge such analyses to have sub-optimized or mis-specified the actual management problems confronting those responsible for decision-making in the field.

Not surprisingly, the history of decision-making has evolved piecemeal and without benefit of compelling or thoughtful analyses. Decisions have been reached, where they have been made at all, in a crisis atmosphere of last resort measures taken to protect special local interests during the final phases of stock depletion; 16/ they have been short-sighted and patently unmindful of longer range consequences; 17/ they have substituted bogus conservation arguments for actual economic ones; 18/ and they have shown precious

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14/ A reading of International Council for the Exploration of the Sea, Cooperative Research Report (Report of the Ad Hoc Meeting on the Provision of Advice on the Biological Basis for Fisheries Management, Charlottenlund, Denmark, February 1977), can only lead to this interpretation of the current state of affairs.

15/ The economic critique is variously spelled out in Lee G. Anderson, ed., Extended Fisheries Jurisdiction (Ann Arbor, Michigan: Science Press, 1977), where arguments for a well-balanced theory combining economic, social, and political elements with the more restricted biological ones are presented; the practical and political critique is presented, often brutally, in U.S. General Accounting Office, The U.S. Fishing Industry -- Present Condition and Future Condition of Marine Fisheries (Washington, D.C.: Government Printing Office, December 23, 1976).

16/ For example, the "Fisheries Conservation and Management Act" (P.L. 94-265) mandated revolutionary changes in American policies and programmes but did so mainly in response to strident appeals from particular interests and without much regard to basic facts of life about the context in which these changes were to take place; it is a prime example of decision-making without information.

17/ Francis T. Christy and Andrew Scott, The Common Wealth in Ocean Fisheries (Baltimore: Johns Hopkins University Press, 1965), Chap. 2 provides a capsule summary indicative of this contention.

18/ See D.H.N. Johnson, "Developments since the Geneva Conference of 1958 and 1960: Anglo-Scandinavian Agreements Concerning the Territorial Sea and Fishing Limits, "International and Comparative Law Quarterly, Vol.10 (1961), pp.587, 590-91. The reference is to Iceland.

little concern for the related objectives of open access to a primary resource, stock identification and maintenance, and equitable economic return for fishing effort. 19/ With the notable exception of the International Whaling Commission,

> which has had responsibility for a species on a world-wide basis, the activities of the commissions have been generally limited to "convention" areas and a few species.

Such activities have also been limited to

> data collection and research, as a base for recommending measures for conservation and development. But only the halibut, salmon, and tropical tuna commissions have had their own international staff, with fairly modest budgets. And in these three instances the budgets were almost entirely supported by the United States and Canada.

And, the recommendations of these commissions, often presented without definitive sanctioning power, have concentrated on conservation measures associated with "closed seasons, gear requirements, and catch quotas." 20/ Conservation recommendations, furthermore, have been dominated by biological, not economic or institutional concerns and values. 21/ At least one critical observer of the Pacific halibut industry has gone so far as to point out that a "successful" conservation effort has in fact been economically and socially wasteful, 22/ a contention made more generally and forcefully by H. Scott Gordon: "It is my belief that most conservation policies that are now in operation fail to achieve a rational economic objective and many of them are detrimental to the progress of the fishing industry, the incomes of fishermen, and the welfare of society." 23/

Whether one agrees with this stark list of indictments of fishery management practices or not, all must be concerned with trying to understand why the record is not one to be proud of. Attaining such understanding is not likely to be easily or quickly done; however, an examination of what appear to be prevalent and guiding attitudes of those responsible for the world's fisheries may afford a useful point of departure for the substantial research and practical tasks that remain undone.

19/ Douglas M. Johnston, The International Law of Fisheries (New Haven: Yale University Press, 1965); and Albert W. Koers, International Regulation of Marine Fisheries (London; Fishing News Books, 1973), both make these points in considerable detail, especially with respect to decisions made about tuna, whales, and halibut.

20/ Mangone, op. cit., p.151, for all of the quoted, summary assessments.

21/ Francis T. Christy, "New Dimensions for Transnational Marine Resources," American Economic Review, Vol.60, No.2 (May 1970).

22/ J.A. Crutchfield, "Common Property Resources and Factor Allocation," Canadian Journal of Economics and Political Science, Vol.22 (1956).

23/ As cited in McDougal and Burke, op. cit., p.482.

The Attitudinal Bases of Knowledge and Action

Professionals and specialization

People tend to be trained to think in narrow, linear, and sequential ways about life and problems, whereas very little in the world can be described by those adjectives. De Jouvenel has stated the point well. 24/

> We seem to have an innate liking for figures that are simple, regular, and symmetrical, which we look for in nature and society. But the history of scientific progress tells us of complex organizations found precisely where we looked for simple order . . . . If the human mind had devised the world, it would be a dead world.

The deadening human mind is all too evident in many of the systems we have created to use the world's fisheries resources.

Professionals have been captured by their profession -- its imperatives, perspectives, and tools. Biologists, who are often the first to profess the complexities and richness of the systems they study, have consistently simplified and limited their enquiries to include only a small fraction of the essential elements involved in the world-wide, long-term, changing, and complex context or setting of fisheries. They wear biologists' glasses. Politicians wear glasses of a different refraction and tint, administrators wear yet another and so forth.

To be a specialist means that one has concentrated on a limited field of knowledge. But there is a mismatch between the narrow and highly concentrated information dealt with by a specialist, the somewhat more general and comprehensive information required by managers of the fishery resources, and the broad and grossly detailed information required by an elected official (who has responsibility and authority to create the reality of fisheries policy and programmes) and the average citizen, whose individual and collective acts certainly effect system outcomes. This fact has profound implications, particularly for the overall analytic enterprise. 25/

For instance, one might try to be introspective about the kinds of analyses that have been conducted in the past in an effort to identify the types of issues which have been routinely considered and, or of equivalent interest, not considered. 26/ What topics, for

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24/ Bertrand De Jouvenel, The Art of Conjecture (New York: Basic Books, 1967), p. 271

25/ M. Marney and N.M. Smith, "Interdisciplinary Synthesis," Policy Sciences, Vol.3, No.3 (September 1972), pp.299-323

26/ The general issue of "what gets studied" is treated with specific reference to houses in William Michelson, "Most People Don't Want What Architects Want," Trans-action (July-August 1965), pp.37-43; I for one am willing to bet that "most decision-makers don't want what fish biologists want" either, although the question is an open, empirical one deserving time and attention.

SOME KEY PARTICIPANTS AND THEIR PERCEIVED PROBLEMS

PARTICIPANTS	PROBLEMS (partial lists, ordered according to imagined saliency)[a]
Analysts: Earth scientists Biological scientists Social Scientists economists political scientists sociologists anthropologists int'l relations Applications areas lawyers ops researchers planners administrators public business nutritionists	Data collection, theory development, methods applications. Topics selected for study rationalized according to disciplinary and professional imperatives and incentives, not comprehensive societal ones.
Managers: Local National Regional International	Budgets; institutional growth and survival; individual advancement; generation and control of specialized information. These general concerns persist through all levels of management, mediated by details of individual context.
Politicians: Local National International	Election; inflation; ego-gratification; protection of constituents' interests; exercise of power (and its accumulation). ["Election" generally refers to the attainment and maintenance of position.]
Fishermen:	
Individuals (owners, crew)	Earn living; survival.
Associations	Maximize special interests.
Processors/distributors	Maximize profits.
Producers of boats and gear	Keep steady or increase demand for products.
Suppliers of stores/fuel	Maximize profits.
Environmentalists:	Conservation; limitation to expansion.
Consumers/Competitors:	
Food users	Steady supply:quality product, lowest price.
Non-food users	Reliable, cheap factor of production
Food competitors (beef)	Keep/expand current market share; profit.
Non-food competitors (oil)	Expand market share at profit.
Mankind, generally considered: Economic subgroups Racial subgroups Geographic/political subgroups	Issues would have to be determined for each subgroup in specific locations at specific times. However, generally will relate to inequality, inequity, interdependence, etc.

[a]These lists are illustrative and speculative; however such information could be determined by various measurement techniques. Doing so would begin to impress the diversity of interests, goals, and objectives that exist in this particular social system.

instance, have analysts selected for study, and what other topics have thus been omitted from their analyses? How have these choices been rationalized?

Many scholars and analysts use the stock rationale that their work contributes to science and to their professional specialties by generating knowledge and fresh insights. A second, and somewhat different, rationale underlying much analytic activity is that the topics selected have been calculated to reward the analyst in terms of increased status, prestige, income, security, and so on. A third possibility is that the scholar-analyst has in fact worked in the interest of a social objective, as indicated by conscious efforts to identify, define, rank and then select research issues in a given context. As a first impression - one that merits careful investigation - it seems clear that problems have been identified and selected for analysis in the fishery area primarily according to the first rationale; such an impression flows from considering who constitutes "society", that is, who are the relevant participants in the fisheries context and what do they consider to be their most urgent problems? The information sketched out in the table on page 91 suggests roughly what is involved here.

Even this partial and tentative list of likely participants forces one to face the fact that problem identification and selection are very complex and rich topics indeed. Not only are the lists of likely problems different for each participant group, but the lists will differ from one location to another and over time for the same classes of participants. A tuna boat skipper in San Diego is not interested in the same things as the President of the Sierra Club; it is a safe bet that a Japanese housewife's present and future lists of issues are different from those that bother her American counterpart. As obvious as that fact is, once stated, it is distressing to see just how little attention analysts have given to it in the conduct of their affairs.

Assuming that the analyst chooses to be guided by social objectives, his burden is to determine in numerous ways what the dominant issues in fact are. Because this is a heavy burden, much research and analysis today are rationalized more according to the imperatives of the individual scholar-analyst's discipline than by the imperatives of a given society at a given place and time.

When one arrays potential issues for study in this way, several important questions emerge. What portion of a given context's problem-issues has been selected for study and hence is judged to be more important? 27/ Whose preferences and biases are reflected in the items selected for study? 28/ Why have other portions of the problem space not been created, and what are some likely results? 29/ To what extent do the selections represent

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27/ For a relatively concrete treatment, see Garry D. Brewer, "Analysis of Complex Systems: An Experiment and Its Implications for Policymaking," in Todd R. La Porte, ed., Organized Social Complexity: Challenge to Politics and Policy (Princeton: Princeton University Press, 1975), pp. 175-219

28/ John G. Kemeny, "A Philosopher Looks at Political Science", Journal of Conflict Resolution, Vol.4, No.3 (September 1960), pp.292-302, at pp.295-96

29/ P.R. Gould, "Structuring Information in Spacio-Temporal Preferences," Journal of Regional Science, Vol.7 (Winter 1967), pp.259-274

the preferences and needs of the general society as compared with the preferences and needs of the individual analyst and his profession? 30/ And how are the implications that follow from this treated? 31/

These are important matters, for the selection act represents what our French colleagues refer to as a déformation professionelle: specialization in the interest of a sharpened and narrowed focus that prevents one from being concerned with all matters lying outside this focus. 32/ We all need to be reminded that any one narrow view alone is insufficient to understand and manage a complex subject or situation; concentrating on the selection process is such a reminder.

Methodological biases

Concentrating on the dominant methodological paradigms used to understand a complex decision environment is another way of being reminded. 33/ Different scientific disciplines rely on related but somewhat different methodologies. Specialized disciplines may generate specific narrow insights about selected aspects of broad, complex, and not-well-understood general phenomena. However, the specific and narrow view is seldom a sufficiently robust one to describe or comprehend these phenomena or to locate them within a broader context of decision. Thus a biologist can extend his expertise to other areas, e.g., the characteristics of aggregate populations of fish of many species could be determined based on a detailed knowledge of individual species, and can often offer valuable insights to assist the marine decision maker. But the same biologist, pondering the less technical, less familiar aspects of the broader subject, e.g., creating feasible compliance strategies to prevent overfishing, might try to extend his models and concepts to these aspects without generating any truly productive insights at all. The result may be a misplaced reliance on technical experts who are working beyond their substantive competence, especially when they are working with rigorous and often hard-to-understand methods and techniques. In the same vein, the economist is often moved to press his theoretical expertise into areas where the theory has at best partial applicability, and the results here are also often questionable or even counterproductive. 34/

30/ This is an old, well-known problem. John Dewey, "Theory of Valuation," International Encyclopedia of Unified Science, Vol.2 (Chicago: University of Chicago Press, 1939).

31/ Harold D. Lasswell, A Pre-View of Policy Sciences (New York: American Elsevier, 1971), Chaps. 5 and 6.

32/ William Barrett, Irrational Man (Garden City, N.Y.: Doubleday, 1958); and idem, The Illusion of Technique (Garden City, N.Y.: Doubleday, 1978), provide two penetrating assessments and analyses of this profound problem.

33/ Several of these ideas were first formulated in Garry D. Brewer et al., "An Integrated System for Fisheries Management: Comment and Observations" (New Haven, CT: School of Organization and Management, Working Paper, August 1978), pp. 3-5.

34/ David Novick, "Mathematics: Logic, Quantity, and Method," Review of Economics and Statistics, Vol.26, No.4 (November 1954), pp. 357-358, is especially telling on this point.

This is not to say that extending diverse theories and methods to subjects different from those in which the basic work attained legitimacy cannot occasionally provide insights. It merely says that such insights are not numerous nor are they guaranteed. It also says that the selection of topics, the structuring of the problem, the application of a method and the formulation of results all eventually hinge on the judgement, knowledge, and skill of the analyst in carrying out each of these tasks. 35/ These facts have been neglected, and the importance of the analyst has been over-shadowed by a misplaced emphasis on techniques - which shall always remain at base judgmental and limited in nature. 36/

Decision-making biases

Prevalent biases evidenced by decision-makers are important, too. As the analyst's view of the world is shaped by a variety of factors, including but not limited to his training, personality, and past experiences, so is the decision-maker's. A marine biologist recently transferred from a laboratory or experimental station to Washington or Rome and a managerial function will have a view of the world that is strongly shaped by field-oriented, environmental cues, incentives, and pressures. These influences translate into an entirely different language from that used by decision-makers, and difficult problems of respect, communication and coordination between expert and decision-maker regularly flow from these differences and the biases they represent.

The ever-present constraints of budgets, time, organizational demands, and personal and career motivations all enter into considerations of the real world of policy and decision-making. Many managers never learn, or learn only over time and at some expense, that various experts being relied on are not speaking one consistent language, even among themselves; furthermore, there is no way, short of hard-won, on-the-job training, for the manager to find out that there are unresolved coordination and communication problems among experts and between experts and decision-makers. Learning the languages, and appreciating the underlying biases they represent, is a necessary first step toward being able to make responsible assessments of the specialized information experts are thrusting forward for policy attention. In a sense, the manager is "caught" in the middle.

Attitudinal biases

As important as gaining an appreciation of la déformation professionelle is, it is probably equally important to think seriously about the fundamental attitudes that shape the perspectives of those who participate in any given problem setting or context. The following, illustrative, exercise is indicative of a larger, continuing exploration that needs to be undertaken.

35/ Ralph Strauch treats this problem skillfully and in detail in "'Squishy' Problems and Quantitative Methods," Policy Sciences, Vol.6, No.2 (June 1975), pp.175-184.

36/ Much has been written about this, although the impact of this literature has not been strong or well integrated into actual research practice. On the first point, Edward S. Quade and W.I. Boucher, eds., Systems Analysis and Policy Planning (New York: American Elsevier, 1968), Chaps. 1, 18, 19, make the conventional arguments. With respect to limited penetration and impact, Harold Orlans, "Neutrality and Advocacy in Policy Research," Policy Sciences, Vol.6, No.2 (June 1975), pp.107-119, makes a very strong case.

Spatial orientation. As opposed to a worldwide perspective that one ought to find, much fishery research and decision-making seems to have been dominated by narrow, local, and individual perspectives of the problem. Such an orientation is reflected directly in concerns about "the tragedy of the commons," 37/ and indirectly in acts blatantly taken in favour of special or localized interests. 38/ It is an orientation that is best captured in analogies to situations of pure conflict so well known in the game theoretic literature. 39/ While this is not the place to discourse on various details associated with game situations of conflict and cooperation, it is important to state that the stark options they present are often significantly tempered in the real world of decision by the inclusion of increased numbers of players or participants and by the presence of institutional mechanisms whose primary function is to temper and enrich the decision context. 40/ With respect to the current discussion the point is simply made: The management of the world's fishery resources has too frequently been perceived as if it were a simple situation of pure conflict involving a relatively small number of participants; furthermore, adequate institutional mechanisms to redefine and temper this perception and consequent decisions probably do not exist in sufficient number or diversity to allow altered and improved practice.

Temporal orientation. Time is an important aspect of decision-making. As the time available to make a choice decreases, both the search for alternatives and the opportunity to do analysis decrease and may force intuitive decision-making behaviour to take over. Intention yields to intuition. In a crisis setting the decision focus is narrowed and intensified on a select few alternative courses of action. The number of advisers consulted decreases, the amount of effective new information brought to bear on the problem decreases. As the competitive aspects of the situation increase, analytic thoroughness and precision both fall by the wayside. 41/

Consider a setting where the time available for decision-making is decreasing and competitiveness is growing, and suppose that there is an increase in the magnitude of the problem that absolutely must be considered. Likewise, suppose the levels of uncertainty about both the problem context and possible outcomes for the various choices increase. As human, practical limits are approached, organizational fragmentation is likely to occur. With it, one must be prepared to deal with sub-optimized, contradictory and conflicting

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37/ Garrett Hardin, "The Tragedy of the Commons," Science, Vol.162 (1968), pp.1243-1247.

38/ The legislative history speaks for itself in this matter, and will continue to do so until fisheries policy is cast in terms of the totality of the world's resources, needs and productive capabilities. McDougal and Burke, op. cit.

39/ John von Neumann and Oskar Morgernstern, Theory of Games and Economic Behavior (Princeton: Princeton University Press, 1947 ed.).

40/ For instance, resolution of the classic prisoner's dilemma occurs by the insertion of institutional supports designed to preserve trust through improved communication and information. Anatol Rapoport and A.M. Chammah, Prisoner's Dilemma: A Study of Conflict and Cooperation (Ann Arbor: University of Michigan Press, 1965) is the standard reference; see Coleman, op. cit., Chap.3, for a discussion of methods of resolution.

41/ Graham T. Allison, Jr., Essence of Decision (Boston: Little, Brown, 1971) has become the standard reference on these and related points.

recommendations and points of view. All of these behavioural aspects exist in any event, but they are exacerbated in the high stakes, short-time, crisis setting.[42] If there is an increase in the number and diversity of values at stake in organizations or other complex, organized systems, there will be increased opportunities for participants to be indulged or deprived.

Now consider the setting of fishery management and decide for yourself the degree to which it conforms to the pathology just characterized.

Orientation to permanence and change. A cursory examination of decisions taken in the interests of fishery management leads one to the opinion that permanence has been the primary goal sought by those responsible for the decisions: agreements have been reached to protect the status quo in terms of exploitation, distribution, and means of production; next to nothing has been spent on sorely needed research and development; institutional innovations have been notable by their absence. Research, development, demonstration, and experimentation are all activities indicative of a positive orientation toward change. Together they represent intellectual and technical investments designed to improve practice and productivity, thereby making scarce resources go farther or be more effective; to improve operating systems, thereby insuring that prevalent practice is as effective as possible; and to improve the amount and quality of technical assistance available to those in the field, thereby improving the flow of newly created knowledge into the operational environment. An orientation to change is nearly always marked by numerous, dedicated efforts to generate information and new knowledge; its primary result insures leadership based on the best knowledge about a system, its problems, and its possibilities. In operational terms, such an orientation contributes to the setting up of programme objectives and structures, rather than the running of existing programmes; it aids in selecting priorities based on solid analysis, rather than throwing money at problems; and it aids in controlling large, complex, and hard-to-understand systems, rather than observing them as they plunge along out of control.

In a thoughtful essay, The Step to Man, John Rader Platt has struck the key conceptual features of an orientation to change in terms of organizations yet to be developed and functions yet to be performed.[43]

> But we have no ..... organizations that spend all their time searching deliberately for new inventions and combinations for the solution of social problems. There is no General Electric, no national laboratory, with full-time research and development teams assigned to come up with ingenious ideas of improved social organization and communication and interaction .... The main reason why our solution of social problems lags so far behind our magnificent technology today may be that we have not yet organized the same deliberate search for ideas to deal with them .... Yet "social inventions" are possible, as we have seen, just as possible as technological ones, and might be searched for in the same way.

42/ Experimental evidence supports this view. Mauk Mulder, "Communication Structure, Decision Structure and Group Performance," Sociometry, Vol.23 (1960), pp.1-14

43/ John Rader Platt, The Step to Man (New York: John Wiley, 1966), pp.132-33

These abstractions may be illustrated concretely and, by doing so, the possibilities for creative change become clearer.

Design Considerations

General standards for the design of a fishery management system must in many specific ways result in modifications to the attitudinal and other biases that presently exist. At first glance, the task is monumental and probably hopeless. Not only have we gotten to the present state over a long period of time, but the noted penchant for permanence has yielded institutional and organizational "solutions" to problems that are as resistent to change as they are ineffective. Extensions of jurisdictions mandated by many recent decisions, for instance, will be quite difficult to roll back or modify, despite the certain evidence that the means of production they protect are out-dated and economically inefficient. To assume that our investments in policies and practices are wise and at least partly liable to be amortized as a result of their future appropriateness is dangerous, especially in situations of considerable uncertainty and likely change. This of course refers to what economists call "sunk costs," the accumulation of which renders reasoned and reasonable decision-making all the more problematic. Change in this sense becomes synonomous with failure.

Basically, one would prefer to concentrate on aspects of the problem where the sunk costs (and associated inertia) are minimal. Hence our most general design consideration is to identify and then operate in situations of partial or near vacuum.

A second design consideration, taking a cue from Platt, is to concentrate on the invention of social forms of organization, communication, and information - as these might apply to the general problem of fishery management, defined broadly.

A third feature to be encouraged is concentration of the constituent phases of the decision-making process responsible for marine policies, with the objectives of fostering a fuller understanding of the entire process and strengthening the institutional supports of that process. 44/

Partial vacuum

The quantity, quality, and distribution of the world's fish resources will never be as well or reliably known as they need to be for "scientific" management. The supply of fish depends on many complex factors whose nature and relationships are imperfectly known; furthermore, the interactions between natural fluctuations and those caused by fishing pressure and the environmental insults of man are even less well understood. This is not to discourage or denigrate scientific efforts expended in the interests of improving our understanding of these natural and man-induced complications, it is rather to put such efforts into a more realistic perspective. Not only are there just too many unknown and probably unknowable factors operating to hold out much hope for the development of reliable

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44/ Garry D. Brewer, "The Decision-Making Process and the Formation of Marine Policies" (Paper presented at a Conference on "Formulating Marine Policy: Limitations to Rational Decision-Making," Center for Ocean Management Studies, University of Rhode Island, June 19-21, 1978).

predictive models of the man-fish system, but waiting around for the development of such models is probably not even desirable. It is fairly clear that the lead times available for alerting fishery managers around the world to changes in local fish stock conditions will be short and empirically determined (not forecast).[45/] It is also clear that there are very few things over which direct control can be exerted with respect to different species and locations:

- Fishing units can either be removed or added to production.
- Units can be diverted to more abundant species.
- They can be moved to other parts of the world (to exploit new fisheries or to take advantage of short-term over-supplies in existing ones).
- Fragile or threatened stocks can be protected.

However, not only are the present institutional arrangements ill-suited for rapid or flexible responses to changes in fish stocks (one might even say that they are antithetical to these objectives), but the kinds of information presently collected contribute very little to early warnings of such changes (warnings that should be translated into actions that make the best and most efficient use of the total resource).

For instance, the existence of striking adjustments in ocean currents off of the west coast of South America is known to cause severe fluctuations in the locally available fish stock. Predicting an El Niño, as these adjustments are known, and its detailed biological results, is probably unachievable as a scientific goal; however, promptly realizing that an El Niño season is underway and then taking the necessary steps to limit and redirect fishing efforts are not. Missing are the intelligence collecting instruments that would alert one to the condition and the flexible institutional means that would restrict and indemnify production units that require reallocation. In the absence of such intelligence and institutional supports, inappropriate and damaging fishing practices continue, productive units are in time forced out of the market (often permanently), and the total social return is diminished (again, often permanently). Similarly, degradations of the environment are ill-attended, either in the cumulative case where pressure against fish stocks builds over a period of time or in the case of an environmental episode, such as an oil spill. In the first, or chronic, case, intelligence is not collected in sufficient quantities nor in such a way as to alert those responsible for local fish stocks to take strong remedial actions, e.g., containment or reduction of the pollution and reconfiguration of the local fishing effort; in both cases, chronic and episodic, means of reallocation, indemnification, and more general social compensation do not exist in adequate kinds or quantities.

The "vacuum" in this case has been created by well-intended efforts expended in the quest of predictive management in a situation where reactive management is and will continue to be the dominant mode of operations. This is not a call to abandon basic science initiatives. Hardly. We know precious little and any improvement here should be valued.

45/ This realization is not limited to the single problem of fishery management, but has been demonstrated more generally. William Ascher, Forecasting: An Appraisal for Policy-Makers and Planners (Baltimore: Johns Hopkins University Press, 1978).

Rather it is an appeal to guard these efforts (including their tentative and qualified results) from premature abuse at the hands of various political advocates; it is an appeal to focus attention on quite different informational and institutional mechanisms than those existing presently.

New social forms

Irrespective of the specific forms eventually chosen, design objectives for any new social institutions need to be specified, thought about, discussed, and then arrayed against recommended initiatives to determine whether and the extent to which the objectives are likely to be realized. Several of these objectives can be discerned, although considerable additional work on this matter is obviously required.

The institutions should be minimally coercive, offer positive incentives whenever possible, and should afford a wide range and diversity of choices to those affected by their interventions.

Efforts to create and disseminate knowledge, i.e., enlightenment, about the entire world of fish and fisheries should be emphasized, including positive steps to put this knowledge into practice for the benefit of mankind and society (as contrasted with simply enriching fewer, particular interests). Promotion of the specific objectives associated with and orientation to change, as previously characterized, should be a central institutional commitment.

The institutions should be structured to improve the efficiency and effectiveness of the world's total fishing effort, including sport as well as commercial fishing. Furthermore, explicit concern for the interconnectedness of local fisheries with the developing economic and social systems of the world should be operationalized in all possible ways.

A clear appreciation should be fostered of the importance of fish as a precious resource and means to feed an ever-increasing world population. Misuse of this resource for frivolous or less-than-socially optimal purposes should be discouraged and penalized whenever and wherever possible. Specific methods to improve the safety, health, and welfare of the world's fishermen, that is, their overall quality of life, should be institutionalized as well.

Demonstrations of the best possible fishing practices should be conducted, founded on the research and development findings and recommendations obtained through enlightenment-based efforts of these and closely related knowledge centers around the world. Mechanisms need to be created that maximize the chances for these best practices to diffuse as widely and as quickly as possible.

Any acts taken by these institutions should be assessed according to their contribution to and enhancement of reductions in economic, racial, and regional differences that exist throughout the world.

The institutions should be designed to be as resistant to corruption and anti-social abuse as possible. Procedures of internal and external appraisal should be instituted and applied from the very inception of any proposed institutional innovation to guarantee this outcome.

The respect and dignity of fishermen should be appreciated in as many concrete ways as possible, including their inclusion in problem-specifying and problem-solving activities and in all aspects of decision-making associated with the new institutions.

It is obvious that no one institution will be able to satisfy the entire bill of particulars just proposed; however, serious intellectual and relentlessly creative efforts need to be expended to design many different institutional forms that will, at minimal total cost, advance more rather than fewer of these broad objectives. Accomplishing this will not come quickly or easily, but even partial realization of these design objectives should serve as a confirmation of the necessity and utility of continuing with the task and a stimulus to do so.

Decision-making as a process[46/]

Awareness of the fact that decision-making is not a singular or simple activity in the area of marine policy has been slowly dawning although remedial steps have yet to be specified or taken. [47/] Before any initiatives are taken to change and improve the state of the world's fishing efforts, one must have a clear picture of the elements of a general decision-making process so that these may be set off against both existing and proposed institutional and realistic features of marine policy-making and execution. It is an important task, and one to which we next turn our attention.

The Policy Process

It is helpful to conceive of problems as having a "life", during which time they emerge, are defined and estimated as to their potentialities, are confronted with strategic statements (policies) and tactical measures (programmes) that are expected to reduce or resolve their unwanted consequences, and in time end, stabilize, or worsen as a result of both corrective acts and changes in the problem setting itself. [48/]

Invention or initiation, the earliest phase of the process, begins when a problem is first sensed. At this point, a number of ways to alleviate it may be proposed, including many ill-defined and inappropriate solutions. This phase, marked by a casting about for raw information and even more unrefined answers, should help to sharpen and redefine the problem.

Estimation, the second logical step in the process, deals with risks, costs, and benefits associated with each candidate solution suggested in the invention phase. Estimation implies narrowing of the range of plausible solutions (by excluding the unfeasible

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46/ This section is a summary of a more detailed argument presented in Brewer, "The Decision-Making Process .....," op.cit.

47/ The American situation has been summarized in stunning terms by the Comptroller General: In 1975, the United States "had no comprehensive national ocean program." U.S. General Accounting Office, The Need for a National Ocean Program and Plan (Washington, D.C.: Government Printing Office, Report B-145099, October 1975). One can safely extend this assessment to include decision-making world wide.

48/ This "life-cycle" concept is described in Garry D. Brewer, "The Policy Sciences Emerge," Policy Sciences, Vol.5, No.3 (September 1974), pp. 239-244

or the truly exploitative, for instance) and ordering the remaining options according to scientific and evaluative criteria (such as those postulated above under "New Social Forms"). A battery of sophisticated methodologies, in varying states of development and of varying degrees of suitability or appropriateness, exists for these tasks.

The third, or selection, phase is most easily seen as the "political" step. Someone, usually the policy or decision-maker, must select from the "invented" and "estimated" options. This individual (or collectivity) must strike a balance between the analyst's rational calculations and the multiple, changing, and conflicting goals of those having a stake in the problem and society at large. 49/

Implementation refers to the execution of the selected option. As evidenced by heightened interest in and statements about the failures of policy implementation, this is a phase of the overall process that is little understood, not particularly appreciated, and not well developed. As with the other phases of the process, we need to think more systematically about implementation and to integrate it into the other phases. 50/ Certainly one must understand implementation mechanisms before government (and other) performance can be evaluated and improved, the next step in the sequence.

Initiation or invention and estimation are primarily forward-looking activities. Selection stresses the urgency of the present. Evaluation is basically backward-looking, is concerned with inquiries into system performance and individual responsibility, and is specialized to figuring out how well problems are being dealt with and resolved. Typical topics and questions reflected in the idea of evaluation include the following: What officials and what policies and programmes were successful or unsuccessful in resolving a given problem? How can one assess and measure performance? What criteria were used to make those determinations? Who made the assessment and what were the assessor's purposes? Evaluation is a necessary input to the next and final phase of the process.

Termination is necessary when policies and programmes have become disfunctional, redundant, outmoded, unnecessary, and so forth. From the conceptual point of view, it is not a well-developed phase; however, one should not rate its importance by our lack of understanding of it - as has been startlingly illustrated by recent tax-payer initiatives and by a growing concern in the U.S. federal legislature for "sunset laws" and "zero-based budgets." 51/ How, for instance, can a policy or programme be adjusted or terminated

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49/ It is precisely at this step of the process where many of the attitudinal biases noted earlier come into visible and direct conflict. It should be stressed that politicians, the specialists most directly associated with selection or decision-making, seldom behave in truly irrational ways, as many scientists might contend; rather, a decision-maker's rationality is fundamentally different than that embraced by the scholar/analyst. See Bernard Crick, In Defense of Politics (Baltimore: Penguin, 1974 edit.), for a very sophisticated discussion of this critical issue.

50/ Erwin C. Hargrove, The Missing Link: The Study of Implementation of Social Policy (Washington, D.C.: The Urban Institute, July 1975), is basic reading on this matter.

51/ For additional comments, see Garry D. Brewer, "Termination: Hard Questions, Harder Choices," Public Administration Review, Vol.38, No.4 (July/August 1978), pp.338-344, and other related contributions on this topic in the same source.

without having had a thorough evaluation? Who suffers from the termination? What provisions for redress have to be considered? What personal costs are involved in termination? Can they be met? What can be learned from termination that will inform the initiation and invention of new policies and programmes in the same or related fields? The list of relevant questions is long, but neither these questions nor the fact that termination is linked intimately to other steps in the policy process should be ignored.[52/]

The value of the conception of decision-making as a process is manifold, and several of the possible benefits of this concept are portrayed in the following figure.

POSSIBLE BENEFITS FROM THE CONCEPTION OF A DECISION-MAKING PROCESS

Phase	Possible Benefits
Initiation/Invention	o Recognition of a problem. o Creative thinking about a problem. o Prototypical design. o Crude hypothesis testing. o Preliminary investigation of concepts.
Estimation	o Scientific examination of likely impacts and outcomes of plausible options. o Normative/evaluative examinations. o Development of outlines of a complex policy including programme details. o Appraisal of claims of key participants. o Development of performance indicators. o Specification and estimation of key parameters.
Selection	o Focusing of debate on actual issues. o Allowance for political compromises. o Realistic choice among programme designs and options. o Reduction in uncertainties about options.
Implementation	o Development of rules, regulations, and guidelines for execution. o Development of specific pieces of a programme. o Establishment of performance standards, based on previous estimates. o Minimization of execution costs.
Evaluation	o Comparison of estimated and expected performance levels with those attained. o Assignment of responsibility and sanctions.
Termination	o Determination of whether problem is chronic, recurring, or resolvable. o Generation of information about new problems created in termination acts, some of which may require planning, political attention, and treatment.

52/ The entire issue of Policy Sciences, Vol.7, No.2 (June 1976) is devoted to termination topics and practices.

With respect to this idea of life cycles of decision-making, several crude and summary observations about world fishery practice are worth making.

With the exception of the selection phase, there are few, if any identifiable institutions or individuals who are primarily concerned with the other five phases of the process. Problems have been identified, usually by individuals who have studied and become concerned about the aimlessness, inequity, ineffectiveness and consequences of the ad hoc policies and programmes found at various times throughout the world; however, these cries of alarm have been neither numerous nor have they been acted on with a fraction of the energy and resources needed to "make a difference." Initiation and invention, in short, have been sporadic and unconnected from the sources or power and wealth which could and should have been galvanized to make creative and useful decisions. Estimation has been grossly under-capitalized and neglected. Implementation has been ignored or, at best, left to a bewildering array of offices, commissions, agencies, and authorities, and the results have been far from satisfactory. Few examples of systematic, comprehensive, and scholarly evaluations of the world's fisheries exist; this phase of the process is at best embryonic. Termination, including efforts to modernize and replace inefficient fishing practices, has not even been considered, much less institutionalized in a responsible way.

Taken from this perspective, the design criteria of locating and operating in near or partial vacuums is easily satisfied. The agenda is essentially a blank sheet of paper, but one on which the vaguest outlines of a working programme may be discerned.

An Agenda for Action

No two observers will "see" the situation in exactly the same way or in the same light; accordingly, the topics suggested for future consideration are not likely to be exhaustive of the realm of possibilities nor are they guaranteed to receive uniform acceptance and support. Neither fact should deter one from at least beginning the task at hand, however.

Research Issues

1. To what extent has fishery research benefitted from progress made in related fields, such as but not limited to weather forecasting, water resource analyses, pollution estimates and studies, marketing, demography, nutrition, technological innovation and diffusion, and workplace studies and conditions?

2. What might be done to clarify the attitudes, perspectives, and goals of those who participate in the world's man-fish systems?

3. What are the nature, diversity, and appropriateness of the current and most prevalent methods of inquiry used in investigations of the fishery systems? What are their impacts on problem identification and definition? What are the probabilities of altering and improving on this, e.g., integration of methods from other fields, creation of new methods, adaptation of existing methods?

4. What is the past history of decision-making in this field? How have decisions been made? By whom? With what outcomes? What are the key constraints and limitations to decision-making, and what might be done about them?

5. To what extent have research questions that have been identified mis-specified and misunderstood the current and likely future problems of the fishery system? What are the dominant future problems likely to be, and how do these differ from those treated in current research?

Institutional Issues

1. How might long-range planning agencies be established whose basic functions would include early warnings of cumulative negative consequences from environmental degradation, potential new fishery resources, new marketing possibilities, and basic data collection efforts needed to assess the present and future availability and distribution of all the world's fish resources?

2. How could research and development be financed to ensure permanence, independence, and relevance to the needs of the world's fishermen?

3. How might one structure and organize an international bank for investment concerned primarily with fishery issues?

4. How would one go about creating insurance cooperatives or firms whose main purposes would be to indemnify fishermen in localized disaster areas, to support non-fishing for short periods of time while stocks are replenished, and to encourage retraining and relocation in those cases where a stock has been destroyed?

5. What might be done to relate economic sanctions directly against those whose activities degrade the quantity and quality of the world's stock of fish resources? (For instance, does it make any sense at all to offer environmental insurance to the world's tanker fleet as a hedge against the probability of major disasters?).

6. Could one mint worldwide fishing licences, whose total number could be altered in response to changes in available stocks of fish? What authority would be necessary to do this?

7. Could surcharges be placed on end-uses of the fish resource judged not to be socially optimal? How might this be done? Who would make the determinations of social optimality?

The list is not complete, to be sure. It is not, item by item, of equal importance or feasibility. Both of these concerns are reflected in the following matrix, which hopefully serves as a point of departure for at least part of the formidable tasks that remain to be done.

Finally, it needs to be said once more that whatever initiatives are contemplated and then undertaken, ample concern and attention must be paid to the design objectives outlined in the previous discussion of New Social Forms.

SOME THOUGHTS ON MANAGEMENT

by

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The new regime of the sea based on the concept of exclusive economic zones is a reality as far as fisheries are concerned. The bulk of the important fishing grounds, at least those of familiar types of fish, are already within the areas of national jurisdiction, and its proportion is constantly increasing. International fishery arrangements now made are, to a large extent, under the conditions set forth by the coastal states having jurisdiction over the resources concerned, the other parties having a rather small margin within which they can negotiate. Some coastal states wish to reserve or restore most of the resources within their jurisdiction for the development of their own fisheries, while others are willing to allow foreign fishing under certain conditions beneficial to them. Most arrangements are based on a mix of both considerations. The conditions set forth by coastal states include fishing fees combined with various restrictions on access to the resources, as well as on fishing effort; joint ventures; other contributions in kind; and even trade-offs with non-fishery interests. Most agreements are bilateral. They are also short-lived and keep changing largely according to the wishes of the coastal states.

Nations have just begun to face problems arising from stocks shared by the EEZs of neighbouring states. These problems are complicated and serious. Even if there can be agreement on the level of the total allowable catch from a shared stock there is no set of principles under which this total may be allocated among the neighbouring coastal states. Serious problems can arise from this lack of principles. For example, any resource-rich developing country could build up a substantial fishing capability almost overnight by bringing in a foreign fleet under licensing and other conditions. If her neighbours do the same for the same shared resources, over-capacity could occur in no time resulting in serious over-fishing or economic losses, probably both.

Nobody has yet proposed a sensible and widely acceptable scheme for the management of so-called highly migratory species.

What will be the role of fishery scientists in this general picture? The time has passed for them to discuss an ideal institutional set-up for managing resources on a broad regional basis. As most of the fishery agreements are either bilateral or amongst the small number of countries directly concerned, scientists are, and will continue to be, involved in work directly related to such arrangements. At the research level there will still be some effective regional arrangements, which will survive this critical period. But increasing difficulty will be encountered in bridging scientific findings with management measures to be taken, particularly those relating to allocation. The future role of FAO's regional bodies, too, is not certain. They will continue to be useful as fora for discussion, but it is difficult to predict how deeply and effectively they can be involved in the question of allocation.

Scientists of different countries will try to do at least biological work, including stock assessment, over the entire range of distribution of the stock concerned. This, whether or not there is an international agreement among all the countries sharing the stock. They will have to work by cutting across fragmented bilateral or other agreements of limited membership and do their work on the basis of data obtained through these agreements. They might succeed in doing so and might reach some consensus about the state of the stock or stocks.

Beyond this point, things would depend entirely on the wishes of the governments. They might or might not wish to have scientific advice on specific management measures. On the other hand, if scientists could produce more or less agreed conclusions as to the state of the stock or stocks, this could not be ignored in the consideration of arrangements for allocation. The governments would realize that any management measures would have to be based on the state of the stock or stocks although they usually have to be modified by economic, social or any other considerations.

Under these difficult and changing circumstances, different scientists might take different attitudes toward the problem. Most of those belonging to government institutions would have to do what they are told to do in connection with the bilateral agreements to which their governments are a party. Some might switch their interest from the conventional problems of management to somewhat theoretical exercises involving environment, ecosystem, new multispecies models, socio-economic objectives, etc. I hope, however, that there will be a core of scientists who will stick to their basic role of providing advice on management under whatever circumstances exist at a particular point in history, accepting various constraints but still doing their best. Let us hope that the transitional period will not last too long and a new pattern of fishing activities and a new network of institutional arrangements will emerge in the foreseeable future.

On a world-wide basis an even more serious problem is the lack of expertise in many of the developing countries, some of which have rich resources in waters under their jurisdiction. These countries are swamped with advice, technical assistance, equipment selling, fishing agreement or joint venture offers, international funding proposals, etc. from various sources. A combination of these usually tends to result in over-capacities by building up a fishing fleet and shore facilities too rapidly since they appear to be cheap or sometimes free. Few of these countries do realize how difficult it is to develop profitable fisheries where technical expertise, managerial skill and trained personnel are lacking. The administrators of at least some of these countries are incapable of sorting out good advice and offers from bad ones.

Here again, I believe that scientists with expertise in fishery management could be of assistance in preventing these countries from making mistakes. They are often in a position to tell whether a proposed development scheme is roughly in balance with the available resources.

A GLOBAL PERSPECTIVE ON CONTEMPORARY PROBLEMS IN FISHERY MANAGEMENT

by

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Introduction

Any global view of world fishery management will show that we are not being very successful. Herring and anchoveta stocks are depleted; in many advanced countries an enormous volume of scientific talent is involved in detailed computations of small revisions to catch quotas for numerous individual stocks/areas/countries, when the total effort in the fisheries concerned is far above any economically sensible level; meanwhile the pressure of the demand for fish and attractive offers of investment and other aid ensure that most of these stocks round developing countries that are not yet too heavily fished by any sensible economic or social criteria, will soon become so. While no simple magical solution can be suggested, it is possible to see some ways where improvements can probably be made. For convenience, I have listed these under the agenda items/terms of reference of the Working Party.

Concepts

The detailed arguments about MSY or other objectives have been too theoretical in relation to most fisheries. Management decisions are rarely taken on the basis of such abstractions, but in accordance with local political and economic pressures. I agree with David Garrod that MSY has been mainly employed in practical situations as a guide or point of reference. As such it has been useful but has two drawbacks - (a) it guides one to a point that, by most criteria, involves too great an amount of fishing, and (b) the magnitude of MSY relative say to the present catch does not always tell you if you are fishing too hard - if MSY = 100 000 tons, and catches = 80 000, does this mean that effort can be increased somewhat, or that it is well past the peak or that it is at about f_{MSY}, but there is a bad year-class present. Rather than try and determine some single point that is 'best' - can one indeed expect to have a 'best' point in the light of the many different and partially conflicting objectives in fisheries - it would seem better to develop a family of guide posts that can provide a wider frame of reference for determining fishery policy than the simple MSY. Further, these guides should be expressed in terms of the amount of fishing (the input, which is the quantity that can normally be controlled) rather than the catch (output).

One example of a possible guideline, which is used in the North Atlantic, is $F_{0.1}$ (the point where the marginal yield per recruit is one-tenth of its initial value). Another example is the point where average yield is half the MSY which could give a useful division between stocks that are still lightly exploited, and those for which fishing

is sufficiently heavy for policy makers to have to worry about falling catch rates (c.p.u.e.), and the need to control, in due course, the amount of fishing. We might refer to this, for example, as $F_{CAUTION}$. This is very similar to the Safe Biological Yield used by New Zealand for setting quctas for foreign fleets when relatively little is known about the resource.

Models

While it would be very difficult to classify all the reasons why scientific advice has been inadequate for good management, a brief glance at fisheries in various parts of the world suggest that the absence of good models, or a good theoretical basis for analysis has seldom been important. Much the commonest reason for failure is the absence of adequate data to use the models - a simple plot of c.p.u.e. against total effort gives, more often than not, a valuable and reliable guide to the state of the fishery if it can be applied, but despite the minimum demands on data, even this cannot always be used because of inadequate statistics.

The next commonest reason is the failure to apply existing models. This can be due to ignorance or bloody-mindedness on the part of the scientists, but more often it arises because the pressures of the current system for producing management advice leaves little time for a cool look at what is being done. Too often previous methods of analysis are repeated because that is all there is time to do. The recent reliance of ICES working groups on VPA analysis provides some good (if rather discouraging) examples.

This is not to say better models would not be welcome. The needs are of two kinds - for models that can make the best use of scant data (which may well be simplifications of existing models) and models (probably more complex than existing models) that can deal with situations that are not well described by the existing models traditionally used in providing good management advice. This leads to the demand for models to deal with multi-species problems, stock-and-recruitment, and environmental fluctuations, which have been the common-place of demands for a new look at stock assessment for some time past. The value of such new looks cannot be denied, but at the same time it must be admitted that progress in developing them has been slight, and there could be other ways of dealing with the management problems arising from the failure of existing models. For example, these models did not predict the failure of the recruitment to the Peruvian anchoveta that occurred at the beginning of 1972. The most serious aspect was not so much the failure to predict the recruitment failure, but to react to it in time, and thus preserve what remained from earlier recruitment. A better biological/environmental model could have helped, but probably more helpful would have been a better management policy. An earlier reduction in the excess catching and processing capacity would, apart from the large economic benefits, have given more time to the Peruvian Government to react to the unusual events of early 1972 (which included unusually high availability of larger fish).

The models referred to so far are the biological models of events in the sea (those of Schaefer, Ricker, etc.). Much less attention has been given to models of the management process itself. The implicit assumption has often been that management should be based on perfect information on the resources, and from that information some unique "best" policy can be determined. Few studies have been made of choices of management measures that require less information, or while falling short of the absolute optimum, will be in some average sense "best" in view of the uncertainties. Also largely ignored

is the use of the management process itself to generate better information. This is largely because research, management action, the fisheries, and the resources have not been studied as a complete system - virtually all models deal only with the last of these four elements, plus the elements of the fisheries that impinge directly on the stocks of fish being exploited. Such models (especially if management action is taken to include such matters as investment policy and similar decisions to increase fishing, as well as restrictive measures) could very likely lead to better resource use, even if they are not very complex. These models would go somewhat beyond the bio-economic models called for by Colin Clark (which at least deal with all aspects of the fisheries). For example, if we are to compare effort limitation and catch quotas, we should study the costs of the research needed in each case, the likely errors in the scientific estimates (e.g., of number of boats to be allowed, or of the TAC to achieve a given objective) and the administrative machinery needed (including the errors and variation it will involve), as well as just the impact on the resources and fisheries.

Research studies

Generally speaking the types of research studies that are needed to advise on management are well known to fishery scientists, as are the types of the data that need to be collected. The difficulties lie at the later stages in the decision-making process among the policy makers, and those who determine budgets for research and data collection. The many failures to collect good catch and effort statistics, or to examine length and age composition data and to calculate mortality rates and yield curves, are not usually because the scientist immediately concerned does not know what he should do, or what data he needs. It is because he has not enough time, or staff and other resources. That is, the necessary activities do not receive the priority that they should. This is due to the common practice of acting to solve past problems rather than preparing to meet future ones. Although in the North Atlantic fishery research started largely in response to falling catch rates and the possible need for management, elsewhere the prime impetus has been to increase catches, and develop new fisheries. This has been reasonably successful, but until the problems of too heavy fishing actually occur in their own fisheries, administrators have been slow to appreciate the need to direct scientific studies, and funds for research and data collection towards these activities needed for management.

Shared stocks

These do not seem to offer any fundamentally new problems. The need for close collaboration between the countries concerned, and some administrative machinery, e.g., for compiling comprehensive statistics, will be similar to those needed when most major fisheries were high-sea fisheries. There will be greater opportunities and needs for bilateral or multilateral agreements on, e.g., allocation of quotas or mutual access to fishing grounds than was the case of the division of TACs in ICNAF. Also the bargaining may take account of more points (e.g., location of nursery grounds), as has been outlined by Saetersdal at the last ACMRR session. This will require a greater volume of work by the scientists to provide the necessary facts, but it would not seem to require new kinds of work (though resource assessment specialists and advisors may need to know more about the biology of the fish).

General remarks

Insofar as there is a clear message arising from the earlier remarks it is obvious that the obstacles to better management are not confined to the field of biological research. Many of them occur at the points of interaction between biologists, and those concerned with wider policy matters. Some of the consequences of the poor interaction between various interests and professions include:

(i) investment policies (e.g., low interest loans) which may be valuable or essential in the early phase of development, are continued up to or beyond the time when restrictive management measures are needed;

(ii) the need for management-oriented data collection and research is neglected until actual management decisions are urgently needed. By then it is too late to collect the long series of data which give the best information on the state of the resources;

(iii) when the need for management is brought up as a result of biological analyses, it is too often linked with one specific action (e.g., catch quotas). Administrators tend then to react by finding objections (often quite well based) to that action, as applied to the fishery in question, rather than initiating a dialogue to find what action would indeed be desirable.

Extracts from a letter from B.B. Parrish, Director, Marine Laboratory, Aberdeen to B.J. Rothschild.

1. One of the main developments in fisheries research in the past few years, which is now growing rapidly, is the multi-species or eco-system approach to resource appraisal, both as regards the development of production and assessment models and in biological studies. This development stems partly from the extension of the number of resources sought after in the developed fishing areas - leading to mixed fishery situations - and partly, so it would seem, to the sudden realization by fishery scientists that each resource is an element in an eco-system, having complex interactive predator-prey processes. My view is that while all of this is true, and hence the growth in this kind of approach is necessary, there is a danger that it is allowed to gobble up too much of the limited research resources available, at the expense of what I call the traditional, single species approach, and all the research associated with it. It is my considered view that, except in areas, e.g., tropical ones, where the species mix is too great and complex to do other than treat groups of resources together, it is necessary to continue to collect data for, and investigate the biology and population dynamics of, each of the main exploited resources separately. In particular, it is essential (except where the species mix is so large as to prohibit it) to continue to base fishery statistics collection, and biological sampling systems and related population parameter (recruitment, growth and mortality) measurement, on an individual species/stock breakdown. Such work should continue to form the core of the work and research related to the eco-system approach should be fed in to supplement it along clearly defined lines. The main focal points of this latter work should, at least as a first step, be directed to determining (a) the levels of primary and secondary production in each major ecological (fishery) area, their spatial and temporal changes, and the physical and chemical factors governing them; (b) the food and predator/prey relationships for different life history stages of the main species/stocks exploited in the area. The results of such investigations should provide first a reasonable approximation to the total fish production capacity of the area and secondly, as a basis for judging whether it is likely to be capable of maintaining the biomasses of all of the individual exploited stocks at the MSY or OSY levels predicted from single species models, and thirdly an indication of which species/stocks are likely to be serious competitors with one another and the extent of their interaction. This work should include studies of the relations between changes in diet, food consumption and growth of individual resources with changes in their food supply and other environmental factors.

2. Under the new jurisdictional regime, research on population subdivision into unit stocks, and their distributional properties (seasonal movements, etc.) at different life-history stages has become of much greater importance than previously, especially in relation to determining quantitatively, the division of shared stocks between economic zones.

3. Since it became generally accepted that control of fishing mortality (F) should be through catch limitation measures and VPA (Virtual Population Analysis) became the main analytical method used in stock assessment by many workers, work on fishing effort measurement has tended to be dropped. In many fisheries we have now less information on changes in effective fishing effort than we did ten years ago, and for very few multi-year, multi-national fisheries are we any further forward technically, in being able to prescribe reliable direct effort control systems. Research should be redirected to this problem.

4. I do not feel very hopeful of fully integrated bio-economic models being developed which can be used as a basis for decision making on the management of multi-national fisheries on shared stocks. The general criteria and yardsticks for management in such fisheries are likely, in my view, to have to be based on "biological" parameters such as F and tc, the actual values of each for particular situations being chosen in the light of economic and social factors. There is, however, a need for a close rapport and working together between the fishery scientist (biologist) and economist, especially at the national level, to ensure that national management measures are economically efficient.

5. On the question of the management of research, the main comment I wish to make is that the change in fisheries jurisdiction does not negate the need for international cooperation in fisheries research. The need for close cooperation and collective appraisal of resources remains as strong as ever for all shared resources, and there is a continuing need for the scientific community in different countries to keep in close touch in the development of new ideas and methodology. I think a network of regional scientific bodies, such as ICES, backed up by global bodies such as FAO and IOC, is what we should be aiming for to ensure this.

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